

electronic engineering

November 1976



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This month's cover illustrates the new rectangular solid state lamps from Hewlett Packard which are currently available in three colours. They offer the designer the facility of flush mounting. Picture courtesy of Hewlett Packard.

electronic engineering

Vol 48, no 585

November 1976

-
- 4 **Comment and Readout:** *Handle with care; Institution appeal; abacus to analyser; research grant; Canadian connection; assessing market needs; last name in μ processors; Shell orders Decca ISIS; Marconi extends synthesizer range; new laminates plant at BXL; European support.*
-
- 17 **Applied Ideas:** *A controlled fixed maximum ramp generator; thyristor switched power supply; simulated inductance for low frequency filter; VDR extends range of control by photocell; circuit converts unipolar supply to dual; retriggerable one shot using a 555 timer; binary/bcd conversion made simple; versatile waveform generator circuit; special purpose analogue to digital converter; filtering capacitor at output has advantages.*
-
- 45 **Global Walsh function generators:** *These functions are widely used in information systems. Using basic definitions S Tzafestas, G Frangakis and T Pimendis show how any type of Walsh function may be realised.*
-
- 50 **Substrate materials are critical for microwave stripline design:** *In microwave application circuit designers must be aware of material limitations, Elaine Williams looks at the effects of these limitations in the light of new material developments.*
-
- 53 **Radar detection in log normal clutter:** *Radar detection has been viewed as exploiting the difference in Doppler characteristics writes D C Schleher. This article examines radar from a statistical viewpoint.*
-
- 61 **European Solid State circuits conference:** *In this article Elaine Williams looks at the main topics of interest at this year's conference which was held in Toulouse.*
-
- 65 **Electronic Ignition:** *An analysis of a typical installation.*
-
- 77 **Product Focus:** *LSI technology in custom design is discussed and compared by Elaine Williams.*
-
- 84 **New Products**
-
- 100 **New Data**
-
- 114 **Classified Advertisements**
-
- 116 **Advertisers Index**
-

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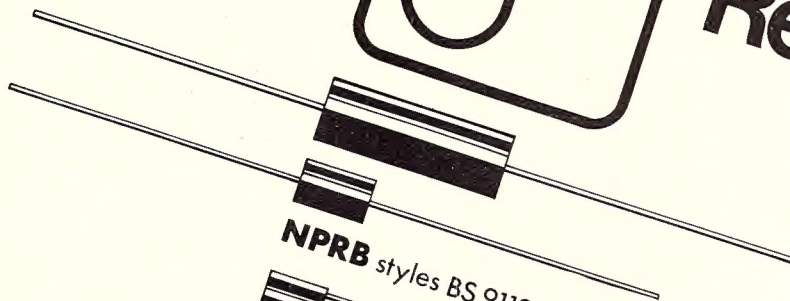
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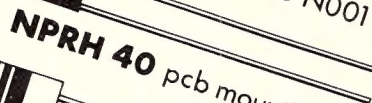
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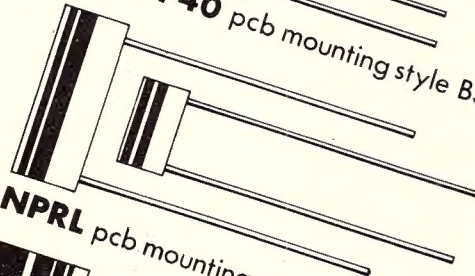
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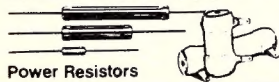
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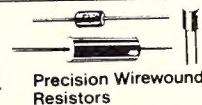
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Handle with care

At last it seems people are beginning to realise that engineering is not an alternative profession when all else fails. For so long engineers have not enjoyed their rightful place in society mainly because society has failed to recognise the need to encourage school children to take up engineering rather than opting for a pure science degree.

Science is becoming more noticeable in the running of our daily lives. We cannot fail to be aware of computers which churn out endless bills and appear dolefully on our doorsteps. Engineering could hold the future to Britain's recovery. The foundations for this should have been laid long ago but society is reluctant to change and is slow to establish the mechanisms to improve itself.

It has wasted many opportunities and channels for steering bright schoolchildren away from arts to the science areas. This is due to many social factors including perhaps a lack of understanding by teachers to the industrial dependence that Britain has for economical survival. Few teachers are able to come into contact with manufacturing industries and therefore cannot give informed careers guidance on the opportunities therein.

One nationwide step that has been taken recently is the announcement of a competition aimed at encouraging youngsters to develop an interest in engineering. Entrants have to produce a device of a mechanical or electronic nature which will be of benefit to society or improve existing equipment.

The competition will run until July 1977 and is intended for students aged 16-17 at school and those aged 18-19 in further education who wish to enter group and individual project work for regional and national finals.

Another unexploited area of talent has been in the female sector. Although the Sex Discrimination Act, which has been in force nearly a year, was brought in to eliminate any inequalities between sexes and provide equal opportunities for all—there is little evidence to suggest this has been the case.

Many learned people in engineering have expounded on the fact that there is little discrimination and companies would welcome girls as engineers but we are still faced with the situation that there are few girls in engineering. Ewan McEwan, Managing Director of Lucas and newly appointed President of the Institution of Mechanical Engineers presented his inaugural speech on the subject of women in engineering.

But whatever speeches may ensue in the future one thing is certain. In order to increase the number of engineers working in industry and ultimately are bringing increased productivity to this country we must begin to educate our children at a very early age that engineering can be an exciting and worthwhile career.

READOUT

Institution appeal

In order to maintain and expand its activities the Royal Institution has launched an appeal to raise £750 000. Sir Monty Finniston leads the campaign as chairman with the aid of the Institution's director, Professor Sir George Porter.

Already a third of the sum required has been raised from private bodies, trade unions, trusts and commerce. The money is intended to be used to expand and maintain the popular schools' lectures which were first started in 1826 by Michael Faraday, to augment the research facilities, and to maintain the premises.

The Institution has been the centre of research and innovation and as Sir George commented "Since it was founded in 1799 the many great scientific discoveries and inventions made at the Royal Institution have transformed the lives of mankind—it is only necessary to mention the electric motor and dynamo, alloy steels, the arc lamp, the liquefaction of gases and the miner's safety lamp to see the truth of this".

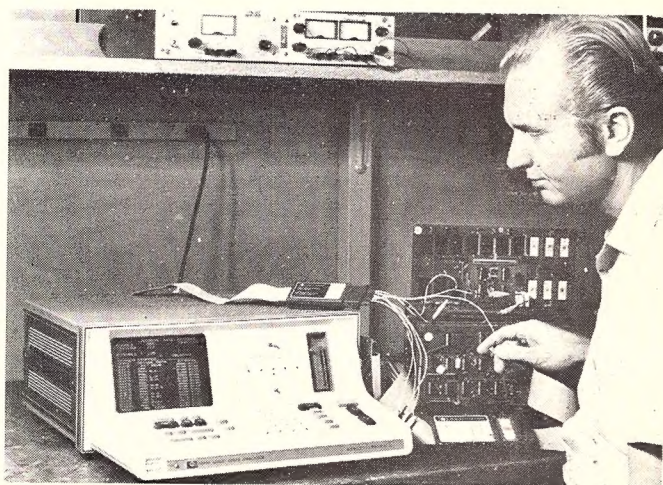
Today much of the research being carried out in the Institution concerns solar energy for which Sir George has a research grant from the government.

Abacus to analyser?

Digital design today is proliferating at an ever increasing rate, creating a need for new instrumentation to analyse digital systems. These digital systems are largely data manipulators with control functions performed by μ P's or minicomputers. To work with, understand and find problems in these data manipulators an instrument was needed that would monitor data transactions and present a visual picture of data flow. This device has subsequently been called the Logic Analyser, a type of instrument that operates in the data domain, in the world of bits, words, addresses, data busses and instructions.

In 1973 Hewlett-Packard introduced the first Logic State Analyser, the 1601L offering many solutions to digital problems. Subsequent developments have led up to the latest equipment, the 1611A, a keyboard controlled analyser dedicated to the design and troubleshooting of systems using 8080 or 6800 μ P's. The 1611A is specialised to one type of system or the other by choice of an 8080 or 6800 personality module.

When connected to the circuitry (at the μ P's socket and simultaneously to as many as eight other points if desired), systems activity can be displayed on the instruments CRT directly in the alphanumeric mnemonics of the particular μ P's own instruction set. With powerful qualifiers, the unit can frame a real-time window around virtually any event, or set of related events. It also accurately measures true execution timing, or counts selected events, as specified by the keyboard. At a point defined by the user, the instrument can halt μ P operations, then, if desired, it can control the transactions that follow, in single or multiple keyed steps.



Research grant

Mobile radio research has been given a boost from the Wolfson foundation. £102,000 has been granted to Professor William Gosling from Bath University to develop his work in the field. The Wolfson foundation gives grants to university research which could prove of benefit to British industry.

Mobile radio is becoming a growth industry since it is estimated that by the end of the century there will be over two million mobile radios in Britain compared with today's 200 000. Also of the £38 million worth of equipment made in the UK £14 million was exported. It is thought that the world market is worth about £650 million.

Professor Gosling's main interest is in using narrower channels for mobile radio transmissions than are currently used without loss of speech quality. One of the main restraints on the growth of the industry is the restricted number of channels that can be used.

Canadian connection

A licence agreement has been signed between GEC and Northern Telecom of Canada allowing GEC to manufacture and market exclusively in the UK NT's SL-1 advanced digital business communications system.

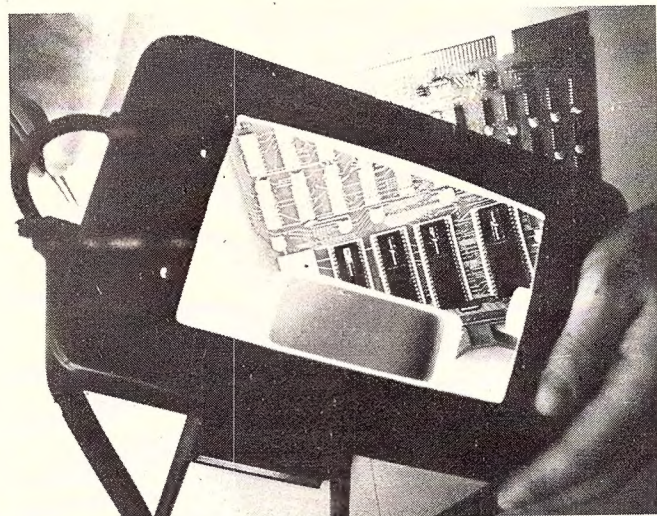
GEC's development laboratories in Coventry have been adapting the system for use in the UK and the company has estimated that the potential market for this equipment could be in the region of about \$70 million a year.

Already the SL-1—which is a large capacity pbx—has become a market leader in North America with orders and commitments received there worth over \$22 million. Northern Telecom claim that over 100 systems will be installed this year.

GEC will market the SL-1 through its subsidiary Reliance Systems in the UK although the licence does allow the company to sell the system overseas.

The SL-1 itself incorporates stored programme control and digital switching techniques. It is claimed to be the largest pbx available with a range of 100 to more than 7000 lines.

Assessing market needs



The LSI 11 microcomputer from Digital Equipment is the company's answer to micros.

Surveying the microcomputer/microprocessor market leaves one with more questions than answers. The market is reportedly growing at 27% (USA 35%) per annum and could well be worth \$75 million (USA \$250/300 million). New applications are appearing daily and new confusions and misconceptions appear just as fast. These range from, when to buy a "ready-made" microcomputer or when to build your own; to simple questions like, what is the difference between a microcomputer and a microprocessor?

It is from the analysis of questions like the above that Digital Equipment Corp designed a series of options to enhance their LSI-11 microcomputer. The '11 is a proper microcomputer, not a stripped microprocessor; containing on a single board the microcomputer, central processor, memory and input/output bus port. All expandable from a choice of six memory and I/O modules, ram, prom/rom or core memories, serial and parallel I/O interfaces, pc-backplane and card guide assembly.

The new options include the DRV11-B direct memory access interface, for the transfer of data between the '11 system memory and an I/O device. Transfer speeds of up to 250 k 16-bit words/s are possible with byte addressing, read modify-restore operation and burst-mode facilities provided.

The DRV11-P bus foundation module is a wire-wrap unit containing the sub Unibus interface, providing adequate board area for mounting and connecting ic's and components.

The MSV11-C provides up to 16k, (8k and 12k options possible), of 16-bit mos dynamic ram, using 4k x 1-bit chips. On board memory refresh circuitry is provided. Battery back-up facilities include the separation of power supply rails allowing the minimum required numbers of components to be supported in this mode.

The fourth option is the KD11-R cpu, comprising the LSI-11 module with no on-board memory and MSV11-C 16k ram module in a dual board configuration.

The remaining two items are the LAV-11 line printer and the H780 power supply, providing +5V at 18 A and +12 V at 2.5 A.

DEC have also laid in a facility at Worcester, Mass. for the production of LSI-11 chips and interface circuits. This facility has been on-line for the past eighteen months and has the capability to fabricate 101,6 mm wafers in n-channel mos.

Al Peters, European Components Group Manager, commented, that the facilities production currently outstripped the requirement, but it was the company's aim to produce semiconductors for DEC's internal requirements, including special devices. Other technologies were likely to be introduced in the near future with SOS or I²L as likely contenders. Western Digital, who up until recently were DEC's major supplier of 4k ram's will now act as a second source.

Last name in μ Processors

Zilog were formed in late 1974 in Los Altos, California, with a brief to design and produce the next generation of microcomputers.

The founders of the company were Dr Federico Faggin and Ralph Ungermann. Dr Faggin's achievements include the development of the original p-channel mos process at SGS and the development of mos silicon gate whilst at Fairchild and Intel, coupled with responsibility for the implementation of the 8080 microcomputer system at Intel.

This background development has led to the introduction in recent months of the Z80, a processor of the next generation. In a short space of time it has become recognised as a potential market leader.

These devices were designed to be super 8080A's, offering 158 instructions including the 78 of the 8080A and a through-put of five times that of the 8080A. The device comprises a cpu, a parallel I/O controller, serial I/O controller, timer counter circuit and a direct memory access controller. There is also a free standing floppy disc based development system. The circuit is implemented using an n-channel ion-implanted silicon gate mos process. It features 17 internal registers, a 1,6 μ s instruction execution speed and built-in dynamic ram refresh circuitry.

Shell orders Decca ISIS

An order has been placed by Shell for machinery monitoring equipment marketed and produced by Decca. The equipment is in the company's ISIS range and will be employed on three oil platforms—the Brent C, Brent D and Dunlin A—which are all east of the Shetlands.

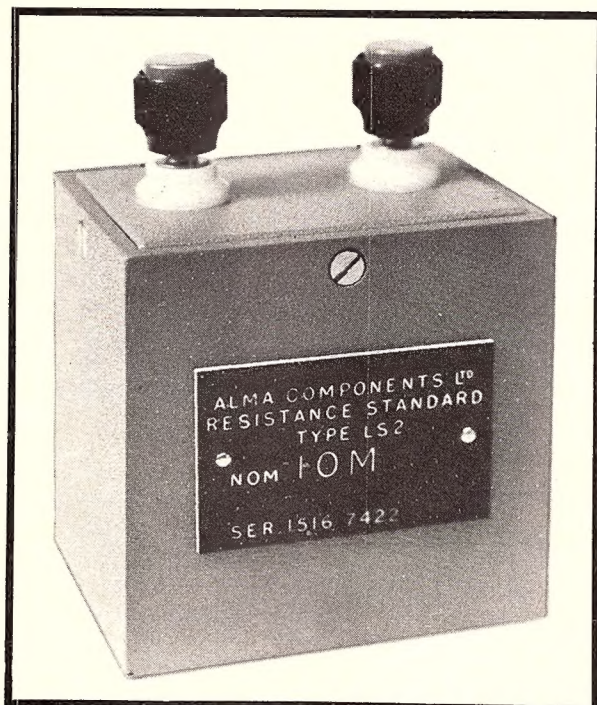
Each of the ISIS 200 systems are to monitor a variety of pumps amounting to a total of 300 points. Parameters such as temperature, vibration, electrical failure and switch signal inputs will be measured as well as providing alarms and displays.

The first of the series of ISIS systems were introduced in 1967 for the marine environment. Most of the equipment so far has been incorporated in rig supply vessels and drill ships.

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Marconi extends synthesizer range

The TF2020 synthesized signal generator with its 50 kHz to 520 MHz frequency range is ideally suited to a wide range of applications. Its excellent side-band noise figure (130 dB/Hz at 20 kHz offset) and its low spurious signal level (90 dB) make it suitable for measurements that were previously not thought possible with synthesizer techniques.

Its introduction into Marconi Instruments range further extends the company's signal generator capability. The unit has full am and fm facilities, a stability >1 in 10^8 /day, very low noise, spurious signals >90 dB down, 20 Hz to 99 kHz internal modulation oscillator, frequency deviation from zero to 300 kHz and amplitude modulation to 99%. All of these functions can be controlled manually by fp-switches or remotely through parallel bcd control. These features together with low leakage and wide output range, from 0.2 μ V to 4 V emf provide a compact laboratory equipment.



Another equipment a low cost signal generator, type TF 2015 is offered in two variations. Basically they are 10 to 520 MHz general purpose am/fm signal generators; the deviation being that the -/1 is a narrow deviation instrument with three ranges 2.5, 5 and 25 kHz fs

whilst the -/2 has a wider deviation variant with ranges of 20, 100 and 500 kHz.

The -/1 is particularly suitable for mobile radio and other narrow band applications where the ease of setting low deviations makes it ideal in manufacture and servicing.

European support

This new facility at Aldershot has been designed to support AVX's push into Europe. Ultimately it will incorporate advanced technology for manufacturing sophisticated and reliable capacitors. These products will be multi-layer ceramics.

A clearer indication of the company's potential can be found by focusing on the long term trends of the industry.

AVX's principal product is the multi-layer ceramic capacitor, one of the most technically advanced passive components used in electronics. Over the past eight years sales of multi-layer ceramics have increased at an annual rate of about 20%. It has been the multi-layer portion of the ceramic capacitor industry that raised ceramics to 30% of the total capacitor market in 1975 as opposed to 14% of total capacitor sales in 1967. Multi-layer products should account for virtually all the future growth in ceramic capacitors, which are expected to double in sales by 1979, commented D Scrantom, General Manager.

AVX Corporation holds the leadership position in the US multi-layer ceramic capacitor industry. An indication of the company's technical capabilities can be found in the range of product innovations and improvements introduced during 1975. Firstly the introduction of Planar, a full product line of multi-layer chip capacitors with thin-foil tabs bonded to the end terminations. The tabs enhance the bonding to hybrid circuit substrates and form a more reliable connection. Another development resulted in a new ceramic casting method that produced a thinner dielectric layer with a 33% increase in capacitance with little increase in size. The company continued development of new ceramic bodies and began limited manufacture of a new ceramic that has the potential to reduce the palladium content required in electrode plates.

It can be seen from this strong foundation that their approach to the European market is a serious one. When main line production gets under way in the next few months, the facility will be equipped with the most advanced production equipment.

New laminates plant at BXL

The new industrial laminates plant of BXL Thermosetting Division at Tyseley, Birmingham, was officially opened by Mr J W Luchsinger, Senior Vice-President, Chemicals and Plastics, Union Carbide Europe. BXL, a wholly owned subsidiary of Union Carbide Corp., USA, announced the beginning of this £2.5 million modernisation and expansion programme in early 1975 to meet anticipated growth in European demand for their Bakelite industrial laminates—particularly in copper clad grades for electronics applications.

The new plant consists of: two multi-daylight presses with automated paper and press handling systems; paper cutting and slitting machines together with an automated finishing line on which pressed laminates are trimmed, cleaned, inspected and sorted and critical parts of the plant situated in filtered air conditions controlled for both humidity and temperature.

Produced at the 34 acre Tyseley factory, the current Bakelite range consists of unclad and copperclad paper and epoxide glass laminates, together with elastomer-clad laminates for capacitor seals and resin treated paper and fabric for use in the

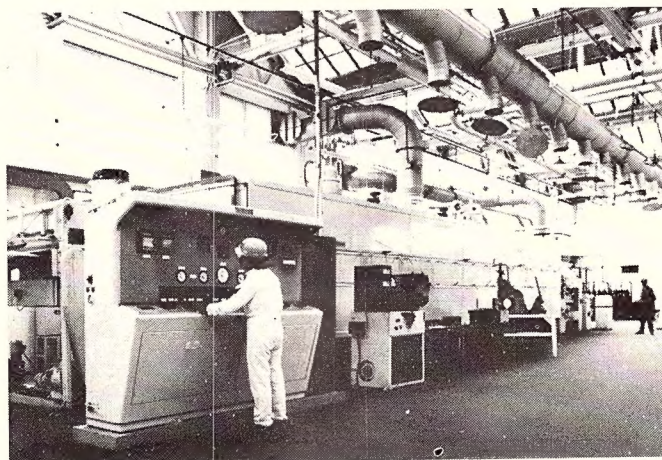
manufacture of rod and tube sections.

The industrial laminates business forms one of the three businesses of BXL Thermosetting. The other two are the bonding and surface coating resins business and moulding materials.

The past decade has seen a significant switch in industrial laminate product mix, brought about by the developing needs of the electronics markets. In the period 1967-1974, the UK market for sheet products overall grew at 3% per annum, but within that period there was a

significant growth in the sectors of consumer and professional electronics, 80% and 70% respectively.

The major end users in the UK and continental Europe for BXL's range of copper-clad Bakelite laminates are in consumer electronics (colour and monochrome television, audio and video entertainment equipment) and professional electronics (computers, telephone exchange equipment and communications systems). Television and audio accounts for 75% of the copper-clad paper laminate market.



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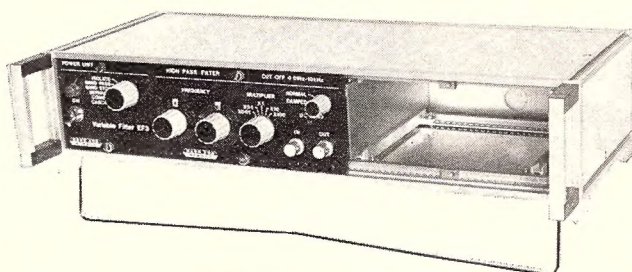
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PRODUCT OF THE MONTH

TREND**UDR 350/700 TAPE READERS**

Trend Communications are market leaders in the tape reader field and have chosen Electroplan to distribute their UDR 350 and UDR 700 Tape Readers in the U.K. These low-cost computer input devices set new standards for peripheral equipment and are already specified by most British computer manufacturers.

These high speed readers employ a patented differential photo-electronic sensing system and capstan drive with a unique electromagnet braking system. Electroplan stock a wide range of interface units and tape handling accessories for the tape readers, together with complete Paper Tape Punch/Read stations.

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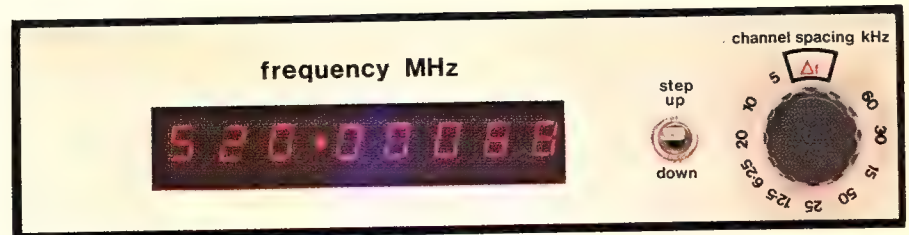
Until now, bought only half the synthesized

Now Racal Instruments bring you a new concept in signal generation — the 9081. Take a good look at its features and see why this Synthesized Signal Generator will become the standard by which others will be judged.

The 9081. Synthesized precision and analogue tuning from 5-520 MHz

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control that gives the 9081 a continuous tuning capability — something quite new in a synthesized instrument. And even when using this facility the output signal is still locked to a crystal oscillator and has a stability at least one order better than any analogue generator.

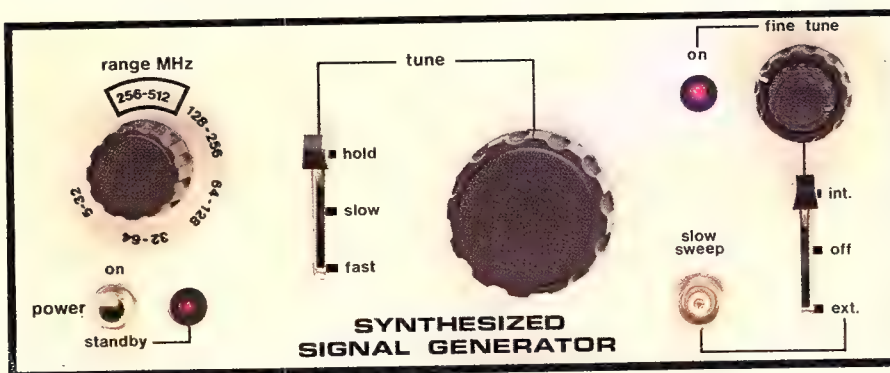
You don't need a frequency meter to check the output, because we've built in an I.s.i. counter that continuously monitors the output frequency and updates the eight digit I.e.d. display. So you are always

The 9081. Channelised tuning

In channelised radio communications the need is to generate precise spot frequencies separated by internationally agreed channel spacings. With the 9081 this couldn't be easier. In fact, it takes just the flick of a switch. Simply select the channel spacing you require, tune to the first channel frequency and press the step switch for the next channel. You can then step up or down through the entire frequency band one channel space at a time. Very fast, very simple, and with guaranteed synthesized precision all the time. We've provided all ten channel spacings between 5 and 60kHz so you can use the 9081 wherever you're based.

The 9081. Automatic Output Levelling.

As you'd expect in a top quality signal generator, the 9081 includes automatic voltage levelling to maintain the output amplitude substantially flat over the whole frequency range — typically within $\pm 0.5\text{dB}$ in fact. There's an accurate switched attenuator and a vernier control which provide an output range from -130dBm to $+3\text{dBm}$. So you can vary the output amplitude from $0.7\mu\text{V}$ up to 316mV into 50Ω .



has a very fast warm-up and a stability of better than ± 3 parts in 10^9 per day. You can forget about the usual add-on extras such as synchronizers or lock boxes — they're just not required.

There's also a fine tune vernier

certain exactly what frequency the 9081 is generating. The counter has a maximum resolution of 10Hz at all frequencies and derives its high accuracy and stability from the same internal frequency standard used for the synthesizer.

- 5 to 520 MHz
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- Channelised or continuous operation
- Stability ± 3 parts in 10^9 per day
- AM, FM and Phase Modulation
- Output automatically levelled

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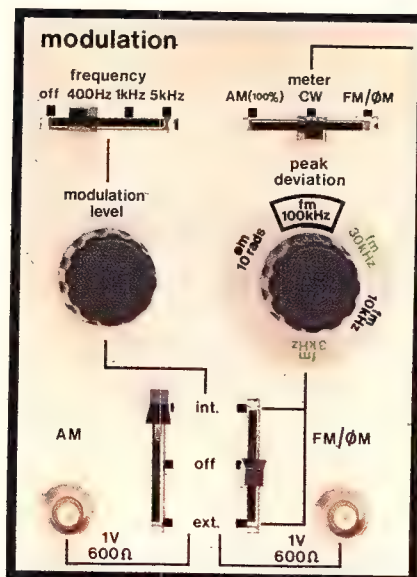
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Signal Generator you wanted.

The 9081. Comprehensive modulation facilities

Full a.m., f.m. and phase modulation facilities are provided to enable you to check most types of radio communications systems. The r.f. output can be modulated either at the fixed 400Hz, 1kHz and 5kHz frequencies provided by the internal oscillator or at other frequencies up to 100kHz if you use an external source of your own. In both cases the front panel meter gives a clear indication of modulation depth, frequency deviation or phase deviation according to the type of modulation being used.

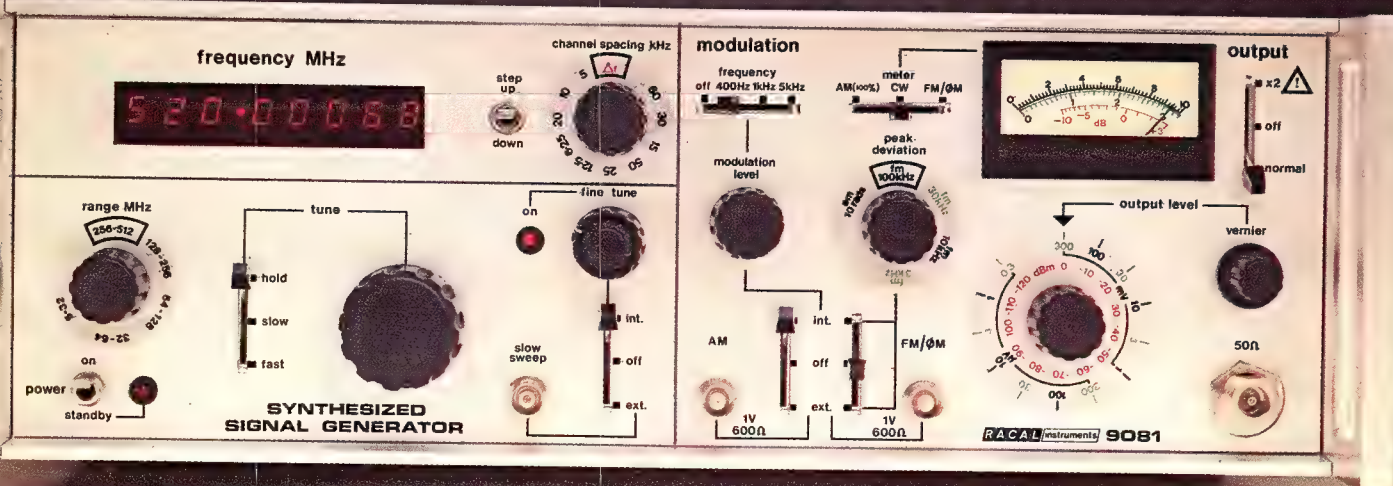
9081 has a simultaneous modulation capability. That means you can modulate with a.m. in combination with either f.m. or phase modulation. And you can use internal or external oscillators to do it.



The 9081 is ruggedly constructed for high performance in both field and laboratory roles. It doesn't just look good. Designed to meet recommended European safety standards and built to satisfy military environmental specifications, the 9081 measures only 133mm x 408mm x 445mm, weighs a mere 13 kg and is readily portable. It's an easy to use, fast to tune, high precision synthesized signal generator and is unique. In fact, the 9081 is unbeatable.

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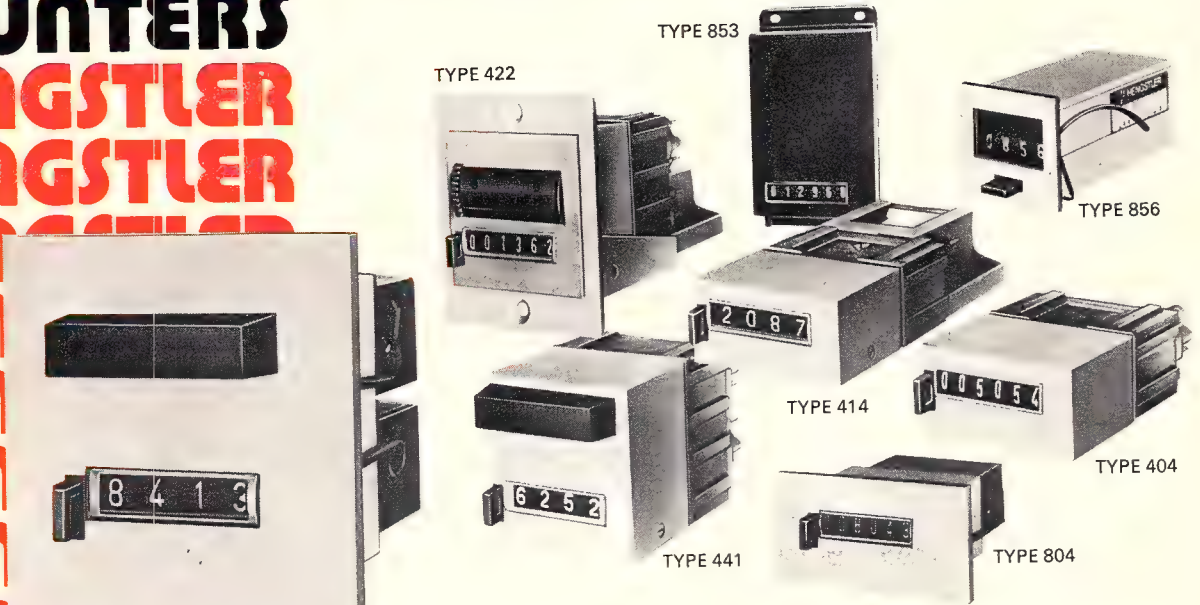


9081

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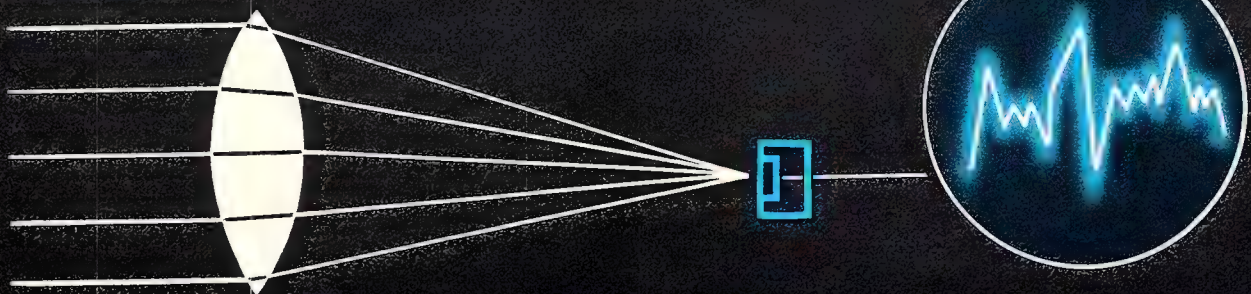
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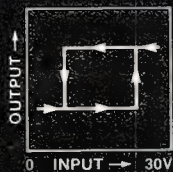


Any system that uses a power supply needs this circuit.

It's the ICL8211/8212 micropower voltage detector.

Any system using a power source between 2 and 30 volts can't afford to be without Intersil's new ICL8211 and ICL8212. Basically, they're voltage detectors which detect and indicate if a voltage has gone below a selected value (ICL8211) as with battery failure or temporary power-supply interruption or above a set value (ICL8212). But their uses are almost limitless.

During their "sensing" or OFF state, they draw only $20\mu\text{A}$ over an input range from 2 to 30 volts... you set the exact voltage with two external resistors. They're super stable: threshold voltage varies only about $100\text{ppm}/^\circ\text{C}$. And both devices can be connected to provide an output with hysteresis, making them great for indicating transitory voltage excursions even after the input voltage has settled back to normal. A few of their many other uses are shown here.



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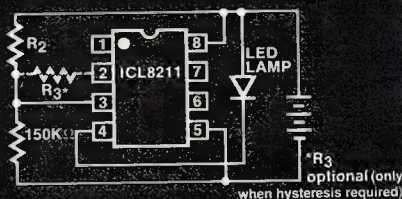
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ICL8211MTY	-55 to $+125^\circ\text{C}$	TO-99 can	£3.87
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ICL8212MTY	-55 to $+125^\circ\text{C}$	TO-99 can	£3.87

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Specification/Application Sheet.**



1. It's a voltage detector.

Use the ICL8211 as a low-voltage detector, the ICL8212 as a high-voltage detector, or both together as a non-volatile out-of-voltage-range sensor/indicator. One popular application, shown here, is as a low battery indicator in portable systems.



Intersil sales representatives

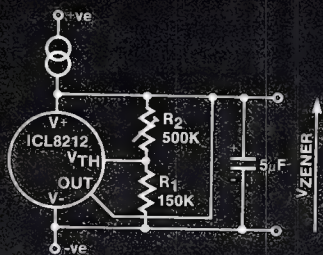
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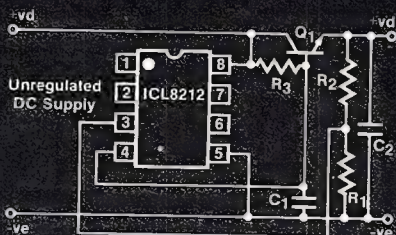
2. A settable reference.

Use the ICL8212 to simulate a Zener reference. Except with the ICL8212 you can set the output from 2 to 30 volts, with a sharper knee than most Zener diodes, and at significantly lower current.



3. A voltage regulator.

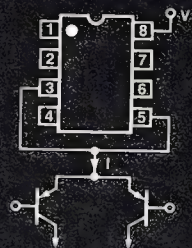
The ICL8212 makes a very stable series voltage regulator, usable with lower input voltages and consuming less power than other regulators. Terrific for battery operated equipment, especially at low voltages.



4. A constant current source, and lots more.

For biasing, the ICL8212 will provide a constant $130\mu\text{A}$, the ICL8212 a constant $25\mu\text{A}$, with a parallel-resistance equivalent in the tens of meg-ohms from 2 to 30 volts.

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APPLIED IDEAS

A controlled fixed maximum ramp generator

A train of pulses of width T secs is applied to the input. The network which comprises two flip-flops, two *and* gates and an inverter allows only a single pulse to reach the *and* gate 3. $T \times 10^5$ pulses are stored in three 7490 counters. These counters are connected in the divide by N mode, where N depends on the number of pulses stored.

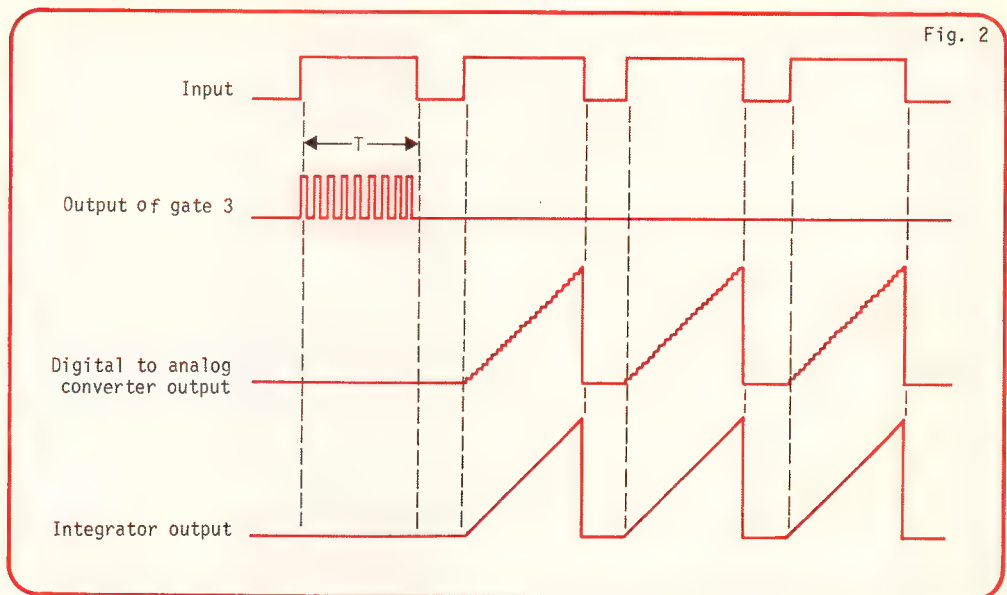
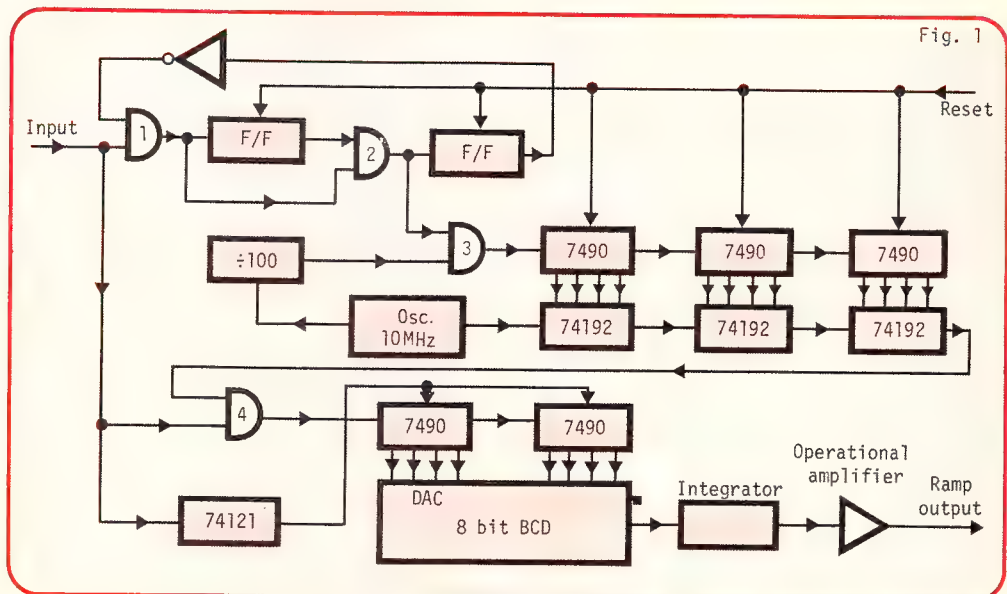
The output of the 74192 is $10 \times 10^6 = 100/T$ Hz. This is $T \times 10^5$

gated by the input pulse train at gate 4. The 100 pulses (per time duration of T secs) are fed to the counters whose outputs drive the digital input of the dac. These pulses are fixed for any time duration of the input pulse.

As the count reaches 99, the dac gives a maximum analogue output. The analogue output passes through an integrator which smoothes the stepped analogue output of the dac. A monostable triggers at the trailing edge of the input pulse and this ensures that the counters are reset to zero when the lower amplitude of the ramp is selected.

The time duration depends on the oscillator frequency and the number of counters driving the 74192 preset inputs. The circuit can be used for sector expansion in oscilloscope displays. An operational amplifier can be connected at the ramp output to obtain the maximum fixed amplitude of the ramp voltage.

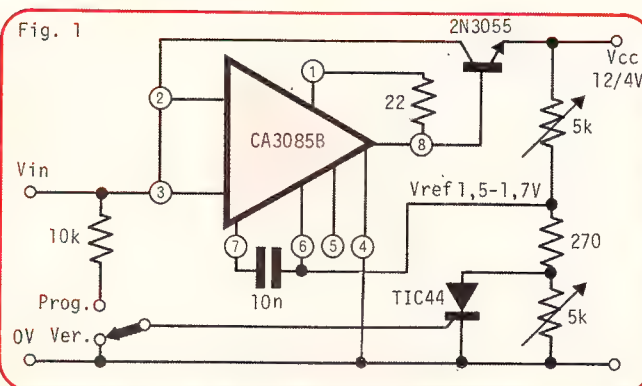
C Venkat Rao and D Bhanumurthy, Ministry of Defence, Chandrayanagutta Lines, Hyderabad 5, India.



Thyristor switched power supply

In building a manual programmer for 1720A proms a power supply had to be provided capable of switching from the programming level of 12 V nominal to a verify level of 4 V, within a time of 1-10 μ secs. The switching was arranged to be manually operated to enable a verify check at any selected address. This necessitated a means of preventing bounce appearing on the V_{cc} output.

An RCA stabiliser CA3085B was used in conventional series configuration. A TIC44 thy-



ristor with dc gate drive from the switch adjusted the feedback potential divider to provide the two required output levels. Due to tolerance in the reference voltage (1.5 V-1.7 V), and forward voltage drop of the thyristor, feedback resistors were left as potentiometers. Values were chosen to allow the thyristor to run at a forward current greater than 3 mA. The output switches smoothly with rise and fall times of one and two μ secs. *J S Rawlinson, British Steel, Motherwell, Lanarkshire.*

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five measurement functions and include autozero. The 8030 is a 3½ digit instrument with a useful diode test facility. The 8040 has 4½ digits and incorporates autoranging.

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APPLIED IDEAS

Simulated inductance for low frequency filter

Line pick-up noise at 50-60 Hz is a common problem when working at very low frequency signals. A very effective method to eliminate this is the use of a high Q notch filter. Figure 1 shows a simple inverting amplifier using an op amp. The transfer function is given by

$$T(w) = \frac{-e_o}{e_i} = \frac{Z_2(w)}{Z_1(w)}$$

By having a parallel tuned LC in place of Z1, and a pure resistance for Z2, the circuit will form an efficient filter. At low frequencies the size of the inductance becomes prohibitively large and the use of a simulated inductance becomes desirable.

Figure 2 illustrates this application. The effective series resistance of the simulated inductance is nearly equal to R4. The value of this resistance is chosen

small in order to obtain a high Q value. The resistance R1 in series with the tuned section ensures that the response is flat at other frequencies. Attenuation between 40 to 60 dB can be achieved at the notch frequency.

The non-inverting version of the filter is shown in Fig. 3. The noise, as well as the signal, is first attenuated to the desired value (60 dB with the values shown) by the potential divider R5-R6. The transfer function is again controlled by the tuned LC stage which is connected between the inverting input terminal of the op amp, and the ground through the series resistance R1. The values of R1 and R2 are chosen so that at frequencies other than the notch frequency, the gain of the circuit is the reciprocal of the attenuation introduced by the divider. At the notch frequency the gain

is unity and the overall attenuation is set by R5 and R6. The non-inverting version has the advantage that the attenuation

can be independently set. *PRM.Panicker, The Government of India, Vikram Sarabhai Space Centre, Trivandrum, India.*

Fig. 1

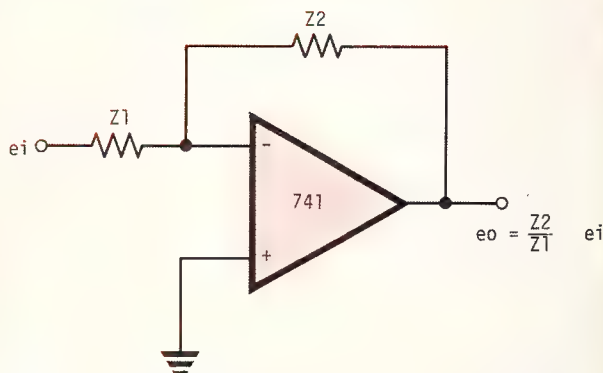


Fig. 2

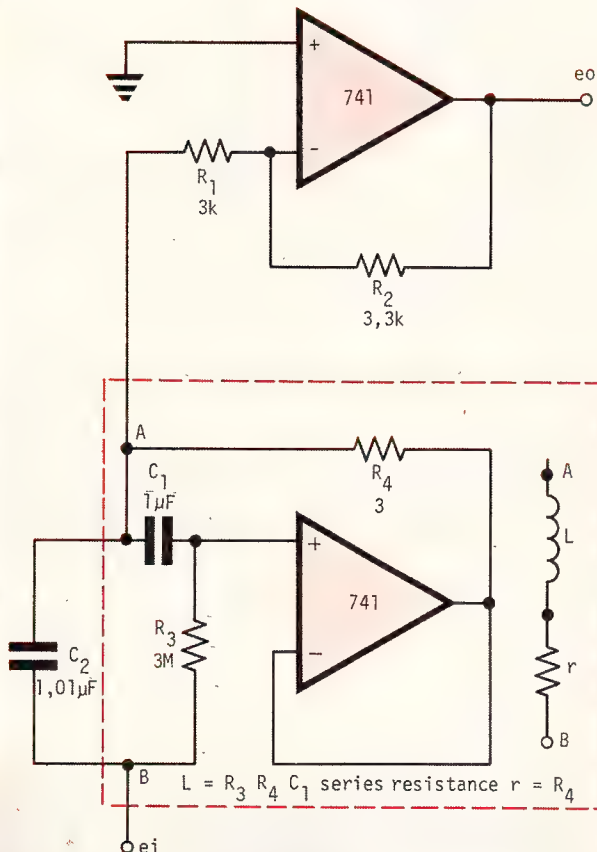
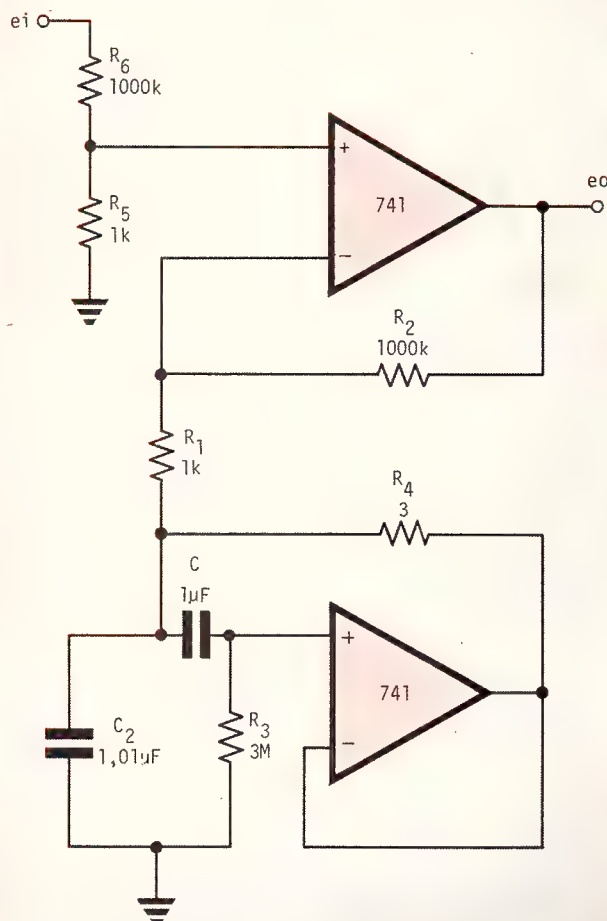


Fig. 3



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RHDP	MAN6710	red	500	125
1½ Digit; Common	MAN6630	orange	2000	500
Anode, Overflow (± 1.8)	MAN6730	red	500	125
RHDP				
2 Digit; Common	MAN6640	orange	2000	500
Cathode; RHDP	MAN6740	red	500	125
1½ Digit; Common	MAN6650	orange	2000	500
Cathode; Overflow	MAN6750	red	500	125
(± 1.8), RHDP			*Typical	

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APPLIED IDEAS

VDR extends range of control by photocell

The human eye can function satisfactorily in ambient illumination ranging from less than 10^{-1} to more than 10^4 Lux. Over much of this range subjective brightness is proportional to the logarithm of illumination. So the automatic control of the brightness of led displays for example, must give a well-graded control over a typical indoor range of illumination from about 0.1 to 1000 Lux.

In one case, a 7-segment led display was found to have good readability in a brightly lit room when the common anodes were connected to a +15 V supply. Reducing the supply voltage gave a graded reduction in brightness, until the minimum satisfactory brightness for a dark room was reached when the anode voltage was about +3 V. This voltage was to be supplied by a series regulator transistor controlled by a cadmium sulphide photoconductive cell. However, the resistance of CdS photocells varies inversely with illumination in an approximately linear manner over the range required, so a simple potentiometric circuit such as that shown in Fig. 1a yielded an unacceptably sigmoidal control characteristic of output potential versus illumination, shown by the solid black curve in Fig. 2. The output potential fell too steeply as illumination was reduced in the middle of the range, and in dim illumination it was below the required minimum of +3 V.

Replacement of the linear resistor R1 by a non-linear voltage dependent resistor, as in Fig. 1b, gave a great improvement in the control characteristic. The potential drop across a silicon carbide VDR is given by the equation:

$$V = CI^\beta$$

where C and β are constants that depend upon the type of VDR. For the present application, which used an ORP 12 CdS photocell as the light sensor, the Mullard E299DD/P220 proved to be the optimum type of VDR. The values of its constants are given by the manufacturers as: $C = 40$, $\beta = 0.25$ to 0.4. In the circuit of Fig. 1b it produced the control characteristic shown in Fig. 2 as a dashed line. Although this ap-

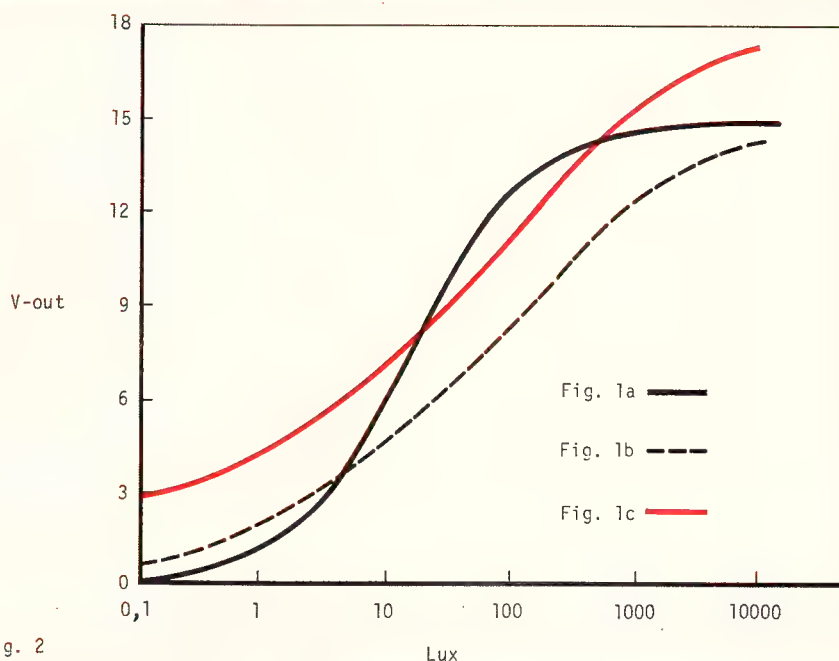
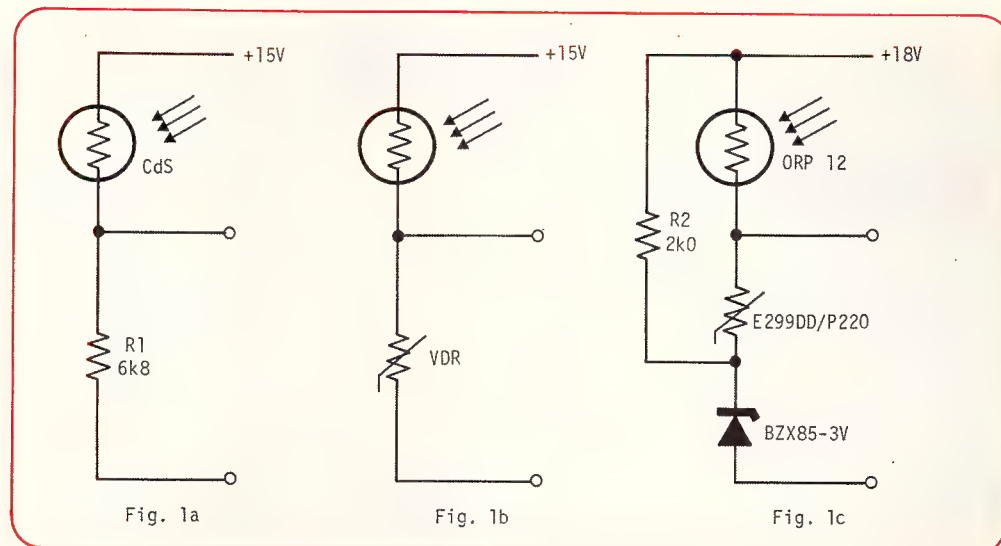


Fig. 2

proximated to the required slope of output potential versus illumination, it still fell below +3 V in the dark and only approached +15 V under brighter illumination than is normally encountered indoors.

The final circuit shown in Fig. 1c, was supplied from +18 V and had a 3 V Zener diode in series to set the required lower limit. Resistor R2 was needed to maintain adequate Zener current when illumination was low and the resistance of the photocell was consequently very

high. This circuit had a control characteristic that varied from about +3 V at 0.1 Lux to +15 V at about 1000 Lux. At 1000 Lux the circuit drew about 25 mA from the +18 V supply—less at lower intensities.

The red curve of Fig. 2 shows that the range of control voltage over 5 decades of illumination was sufficient and the slight downward curvature of the semi-log plot, between 0.1 and about 1000 Lux, indicated ideal control characteristics for indoor applications

the relation between log output V and log illumination being virtually linear within this range.

For different applications the control characteristic curve can be altered, either by employing other types of VDR, having different values of C or β or by changing the Zener diode. In some applications care may be needed not to exceed the permitted power dissipation in the VDR, photocell or Zener diode. *M H Evans, Institute of Animal Physiology, Babraham, Cambridge.*



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APPLIED IDEAS

Circuit converts unipolar supply to dual

This circuit converts a unipolar supply to a dual power supply whose outputs are independently variable. The outputs can be loaded unsymmetrically and the circuit is simple and needs very little hardware.

The circuit is symmetrical about ground being two shunt regulators connected in series. As the circuit is symmetrical we can analyse one half of the circuit only for simplicity.

Assume that B and C are short circuited so that only the V+ supply is active. Any applied dc voltage now appears across A and C. Diode D1 maintains a stable reference of 6.2 V as the bias current is obtained through resistor R4.

Resistors R1, R2 and R3 form a potential divider and this samples the V+ supply and applies it to the base of transistor Tr1. Tr1 compares this sample with the reference, and if there is any error, Tr1 biases Tr2 such that the voltage drop produced in R9 by the collector current of Tr2 compensates for the change in V+ supply.

The output voltage remains constant irrespective of load and supply changes. By varying the potentiometer R2 the output voltage can be conveniently

varied. A similar circuit between B and C provides the V- supply and this can also be altered by the potentiometer R6. The output of both power supplies can be varied between eight and 17 volts so that the standard ± 9 , ± 12 and ± 15 V settings can be made.

The circuit is designed from a maximum load current of 1 A and the output impedance of both the supplies of 0.35Ω . Tr2 and Tr4 should be mounted on a heatsink capable of dissi-

pating 17 watts. C1 and C2 bypass the output ripple.

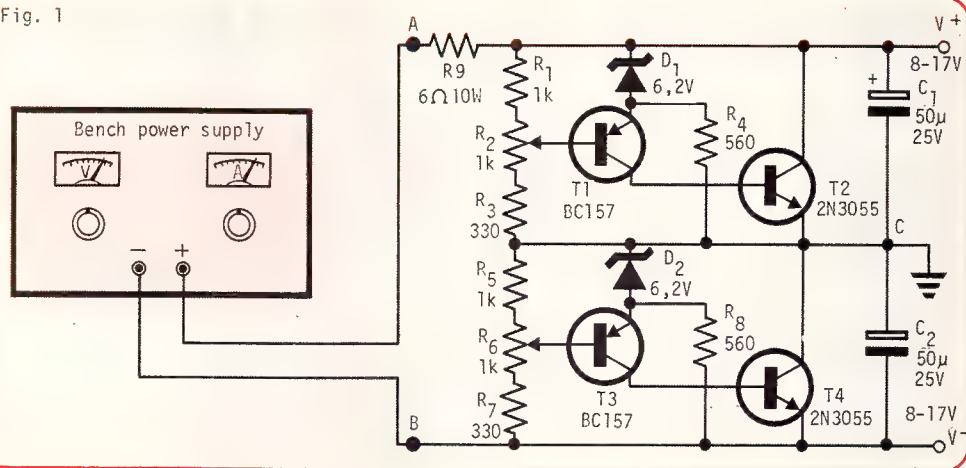
To obtain any voltage, say ± 15 V, the potentiometers R2 and R6 are set for the maximum output voltage. A dc input voltage 2 V higher than the sum of the output voltages (in this case 32 V) is applied. R2 and R6 are adjusted so that V+ and V- attain 15 V.

For any required load current, the input voltage is adjusted such that the current flowing into A (without the load being

connected to V+ and V-) is 50 mA more than is needed. So, for small current the dissipation in transistors Tr2 and Tr4 will be small. The circuit does not have any short circuit protection but makes use of the protection provided by the dc input source. The circuit is ideal for biasing operation amplifier circuits.

S Jayasimha Prasad, Senior Research Fellow, Dept of Electrical Engineering, Indian Institute of Technology, Madras 6000 036, India.

Fig. 1



Retriggerable one shot using a 555 timer

This circuit is a low priced retriggerable one shot having all the advantages of a 555 timer such as long time delay, high fanout capability, large supply voltage range and the time delay is independent of supply variations.

The basic idea of the circuit is to discharge the timing capacitor C by the trigger pulse, which arrives after the initial trigger but during the required delay ($1.1 RC$), so that C can be recharged by R. The total delay is:

$$1.1RC + t_1 + t_2$$

Where t_1 is the trigger pulse width, and t_2 is the delay between triggers. In the circuit, transistor Tr2 discharges C if the trigger arrives irrespective of the state of the oneshot. The time delay starts from the departure of the actuating trigger.

The trigger width should be at least 50 nsec for a capacitance

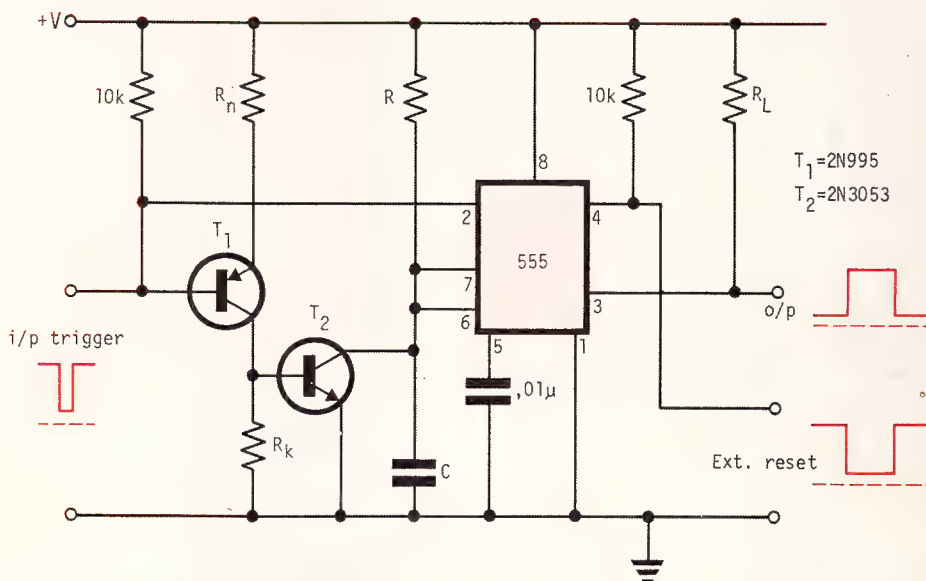


Fig. 1a

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APPLIED IDEAS

of 0.1 μ F as a timing capacitor. For larger capacitances the width should be more so that C is always fully discharged. Transistor Tr2 should be chosen with a high I_c max rating. In order to achieve a clear rectangular waveform at the output a load resistor R1 is required.

To ensure that Tr2 is off during the trigger the resistor Rk should have a low value of between 47-100 Ω . Rk must be less than $R_n 0.6 / (V - V_{hmin} - 0.6)$ where V_{hmin} is the minimum voltage for a logical one. R_n limits the base current of Tr2 when the trigger input goes low so that the I_c max rating of Tr2 is not violated when discharging a larger capacitance.

S Bose, Saha Institute of Nuclear Physics, 92 Acharya Prafulla Chandra Road, Calcutta-9 India.

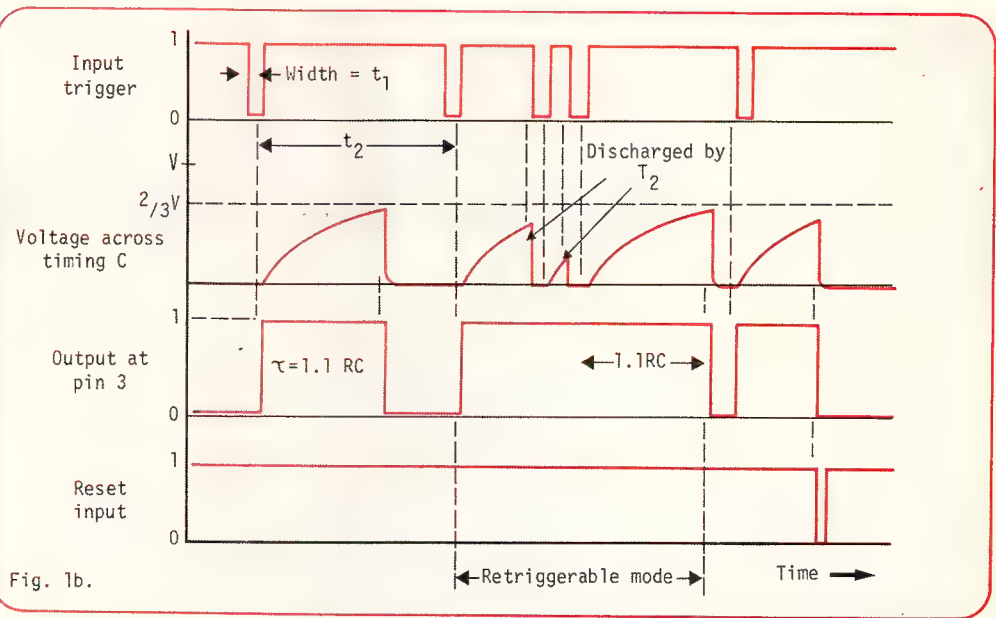


Fig. 1b.

Binary/bcd conversion made simple

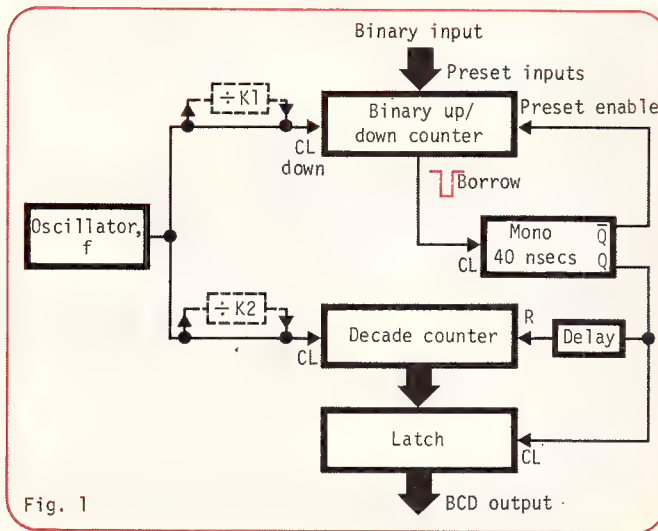


Fig. 1

Fig. 1: Up/down counter simplifies Conversion.

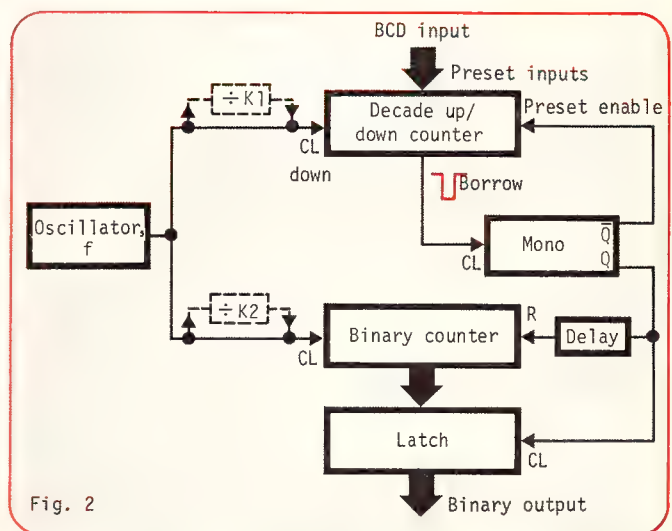


Fig. 2

Fig. 2: Simple BCD to Binary converter.

Most digital circuits today use the efficient binary number system, while the human operators are accustomed and willing to operate in decimal numbers, necessitating the conversions from binary to bcd and vice versa, at the peripherals. Although standard ics like the 74184, 74185A and 7483, are available for high speed conversions, circuits using them become too complex and costly as the number of bits and digits increase. To overcome these difficulties, the counter technique could be used, where the slow speed of operation is not critical. Counter type binary to bcd and bcd to binary converters are described here, which

are simple and faster than that proposed by Seshadiri.

In the binary to bcd converter, shown in Fig. 1, the binary input is preset into the binary up/down counter when the preset enable is low.

The counter starts counting from that value, at the rate determined by its clock frequency, f , till the counter reaches zero. The borrow output goes low when the counter content is zero and the clock is at low, triggering the mono and hence presetting the inputs to the counter.

The decade counter is reset by the mono and starts counting till the next reset pulse. The

latch stores the decade counter output at the time of reset. The mono and a small delay of the order of 10 nsecs between the latch clock and the reset pulse ensures proper operation. The latch output gives the given binary number in the bcd format. The conversion time is $2^n/f$, which is n times faster than that of Seshadiri, where n is the number of bits.

A bcd to binary converter, based on the above principle, is shown in Fig. 2. These circuits are simple and especially suited for higher number of bits, as they can be extended to any number of bits, without much increase in hardware.

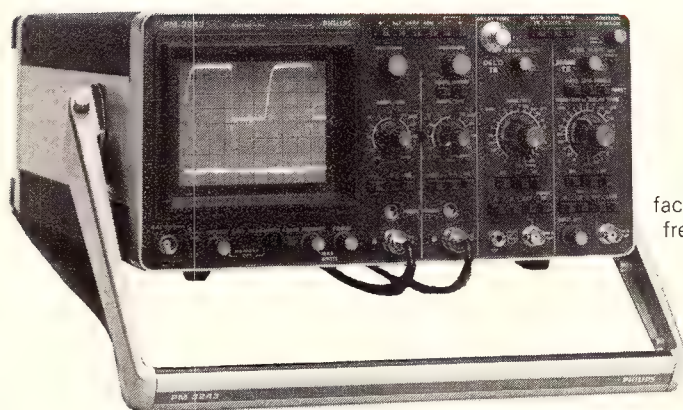
In certain applications, such as the display of a shaft-angle encoder output (binary), it is required to convert K (equal to K_1/K_2) times the given binary or bcd input into bcd or binary number respectively and this becomes too complex in the conventional method. But the same could be done very easily by the circuits proposed here, by introducing frequency divisions by K_1 and K_2 , as shown by the dotted lines in the Figs. 1 and two.

S Murugesan, C Kameswara Rao, ISRO Satellite Systems Project, Peenya-562140, Bangalore, India.

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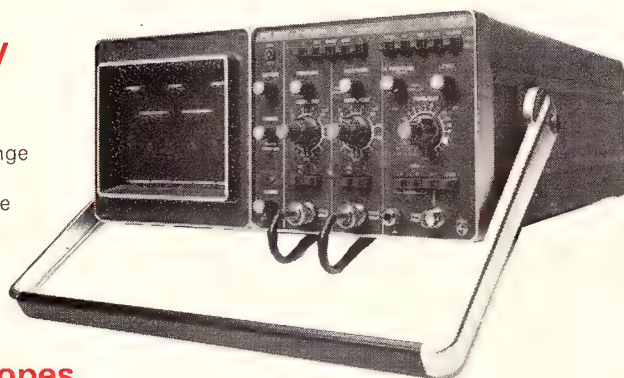
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Versatile waveform generator circuit

The circuit of Fig. 1 can be readily adapted to operate as a triangle generator, sawtooth generator, variable frequency square wave generator or variable frequency pulse generator. It can be used as a voltage to frequency converter, or in many other applications where a voltage controlled waveform is required.

A reference voltage is applied to a low offset operational amplifier connected as an integrator, the reference voltage being controlled in such a manner that it can be switched as an input of either polarity to the integrator.

The integrator output ramps up or down, as appropriate, until it reaches a predetermined level detected by a voltage comparator. The output of the voltage comparator is used to set a flip-flop which in turn reverses the polarity of the reference input to the integrator via analogue switches.

The circuit outputs are drawn in Fig. 2 in the form of triangular and square wave outputs with RV1 and RV2 both set at maximum. Using the component

values of Fig. 1, the frequency can be varied over the range of 20 Hz to 1.4 kHz by means of RV1.

The range can be extended in direct proportion by variation of R3. The amplitude of the triangular wave can be altered by means of RV1 which also causes

a corresponding change in frequency. Variation of the mark to space ratio can be performed by adjusting the value of R3.

Operation as a sawtooth generator with a controlled fly-back time can be achieved by keeping V1 and V2 constant, RV1 is used to vary the sweep

time and the output is taken from IC1/10. If the output is taken from IC4/3, a variable frequency pulse generator can be obtained. The pulse width is adjusted by means of V1.

D S Cutler, Burroughs Machines Ltd, Detroit Road, Glenrothes, Fife.

Fig. 2

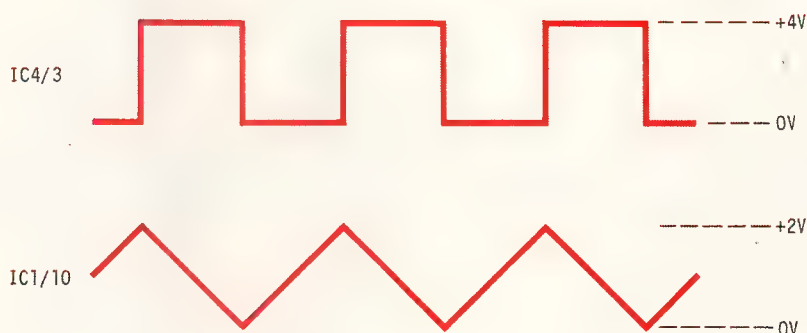
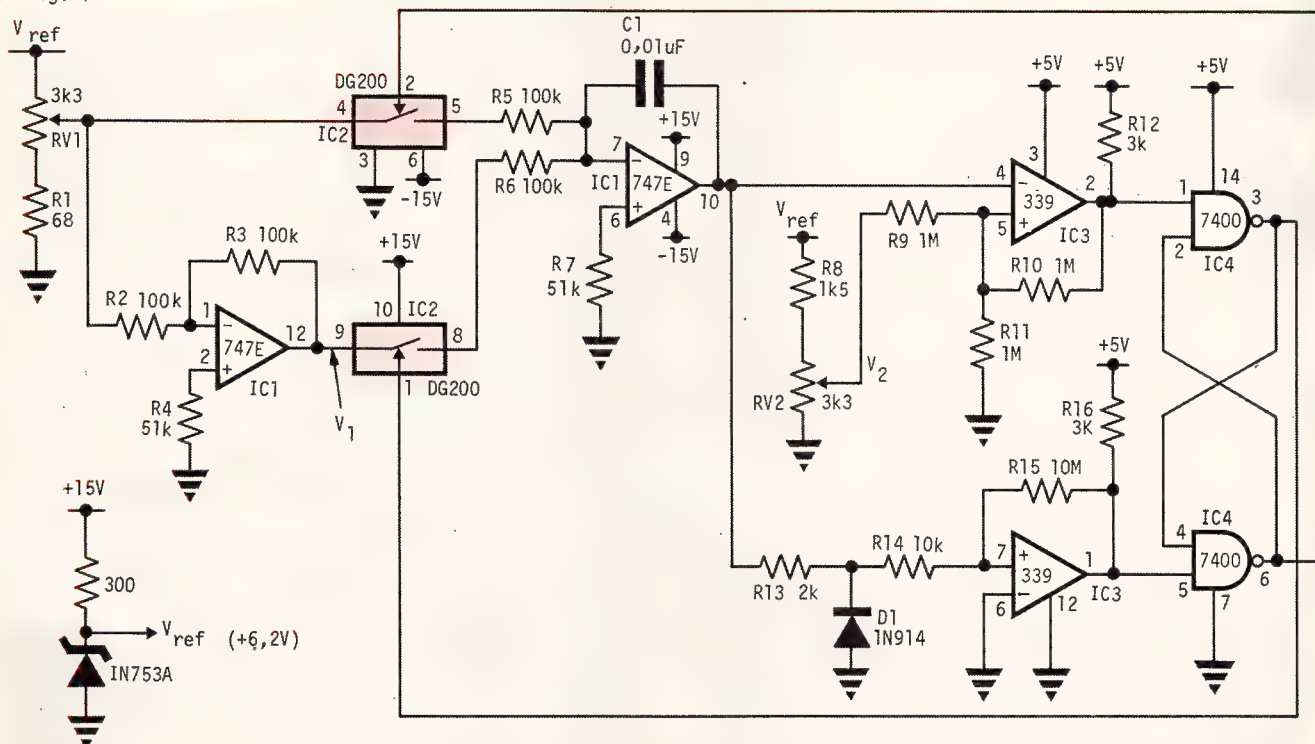


Fig. 1



APPLIED IDEAS

Special purpose analogue to digital converter

This four bit adc provides information about the amplitude of a 100 μ sec pulse. The converter works on the principles of comparators detecting 16 discrete levels. It minimises the number of comparators required by performing an analogue to base four conversion followed by a base two conversion.

In Fig. 1 the analogue input signal V_s is less than 2 V. It is buffered by the unity gain input amplifier A1. The output comparators C1, C2, C3 are all low. Comparator C1's output will go high when V_s is greater than 2 V, while the outputs of C2 and C3 will go high when V_s the signal voltage is greater than 4 and 6 V respectively.

The three comparator outputs form half of a base four code and the outputs are also used to switch the non-inverting cmos

buffers B-3. When these inverters are on they drive current through three resistors to the summing amplifier A2. The output of this amplifier will be as shown in Table 1.

V_{out}	V_s
0 V	< 2 V
-2 V	$2 < V_s < 4$ V
-4 V	$4 < V_s < 6$ V
-6 V	> 6 V

Table 1

So the output of A2 may only assume one of four well defined levels. This output is now combined with the original positive signal voltage at the unity gain of the summing amplifier A3. The output of this stage will be that given by Table 2.

The output of amplifier A3 is

fed into three comparators C4, 5 and 6. These switch at the levels 0,5, 1, and 1,5 V respectively, and they form the other half of the base four code.

The output of comparator C2

V_s (volts)	A3 output (volts)
(0 or 2 or 4 or 6) + Y	0 + Y
(0,5 or 2,5 or 4,5 or 6,5) + Y	0,5 + Y
(1 or 3 or 5 or 7) + Y	1 + Y
(1,5 or 3,5 or 7,5) + Y	1,5 + Y
Where $Y < 0,5$ volts	

Table 2

corresponds to the binary number 2^3 while that of C5 is 2^1 . The

2^0 bit is formed by an exclusive or operation on the outputs of C4 and C5, and oring with C6. Similarly, the 2^2 bit is obtained using C1 and C2 in the exclusive or gate and performing the or function with C3.

The speed of this converter is limited by the switching speed of the comparators. This can be minimised by the introduction of speed up capacitors.

The converter will hold dc levels without the latches or command logic that would be required by a counter ramp converter. It is also free from the least significant bit oscillation that would be encountered with continuous counter ramp converters.

R W Hartley, Laboratory Services Unit, Allen and Hanburys Research Ltd, Ware, Herts.

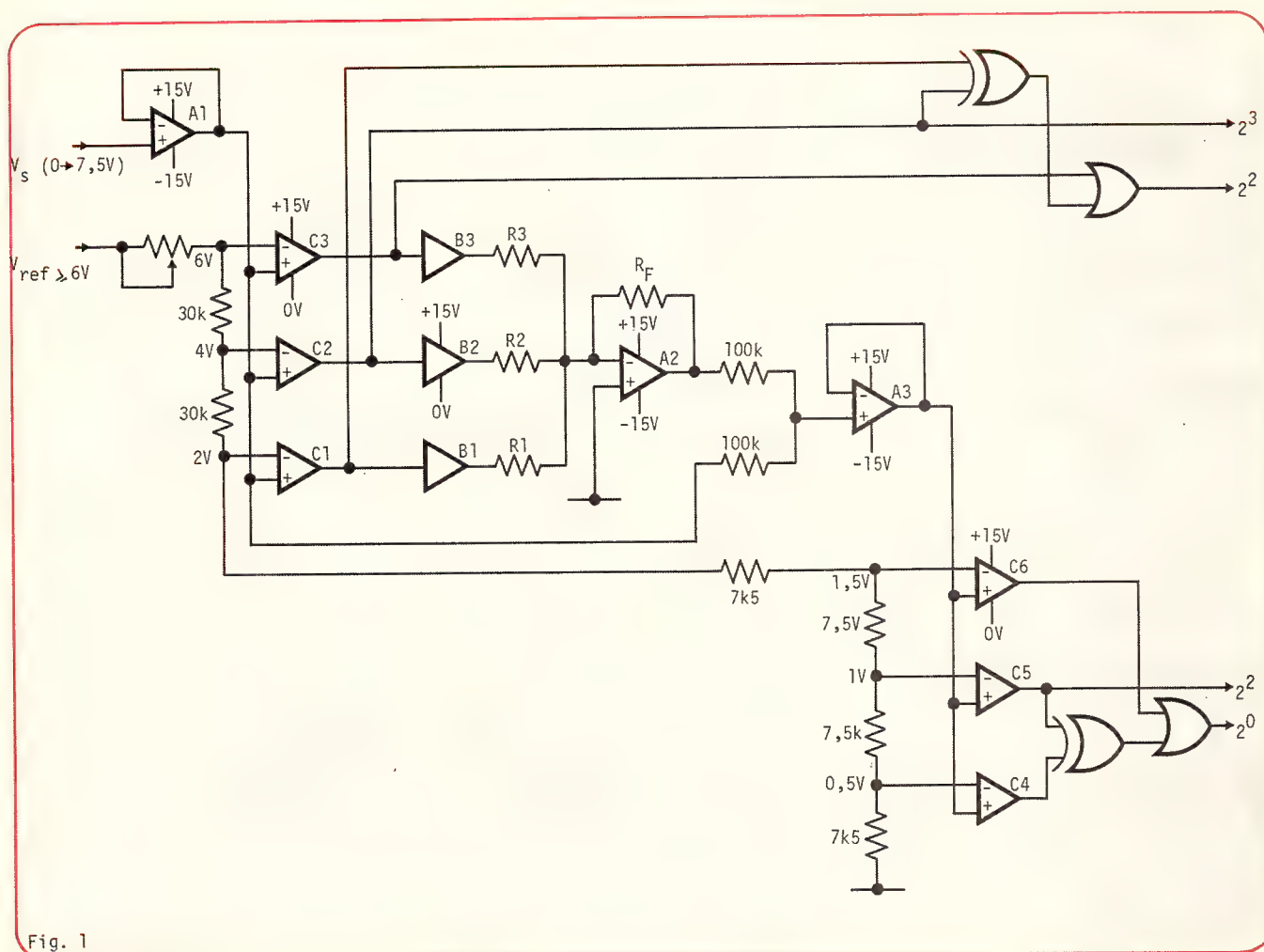
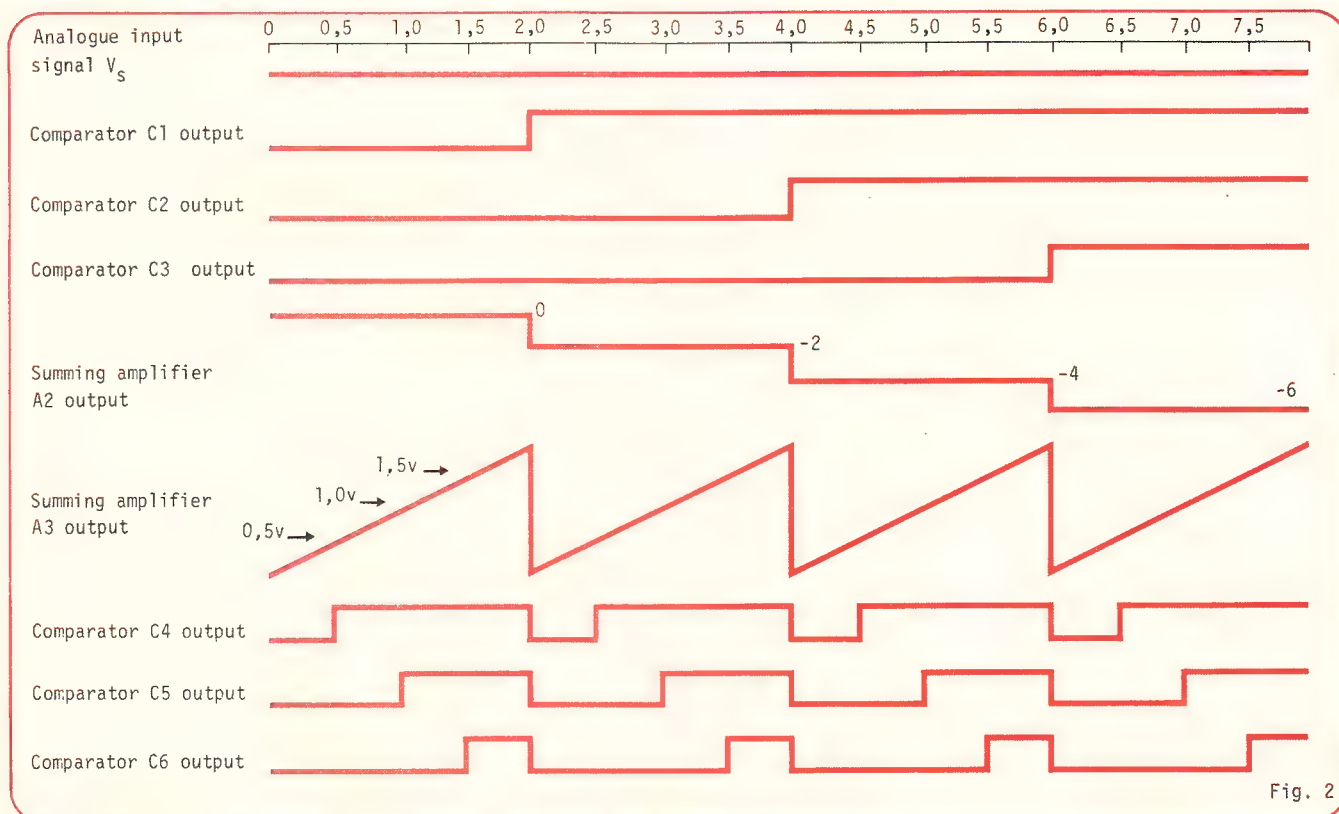


Fig. 1

APPLIED IDEAS



Filtering capacitor at output has advantages

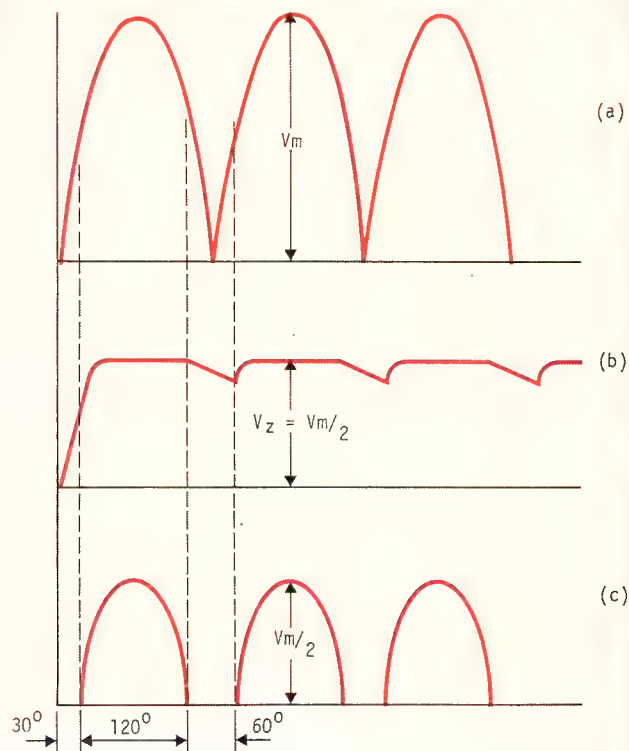
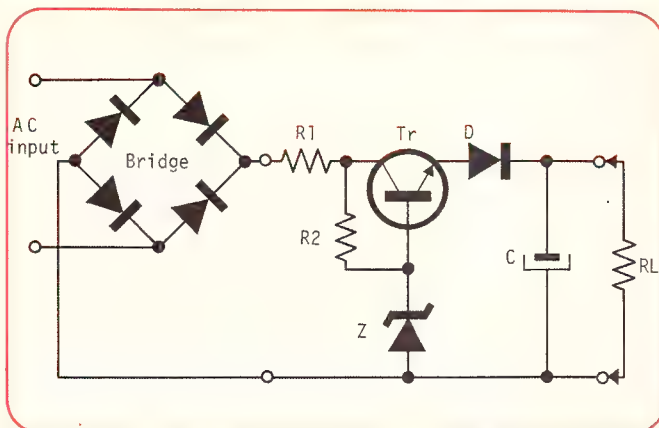
In power supplied where slight ripples of about 5 per cent can be tolerated or where the input varies widely, a filtering capacitor can be used at the output of a series pass regulator instead of the input. It has the following advantages:

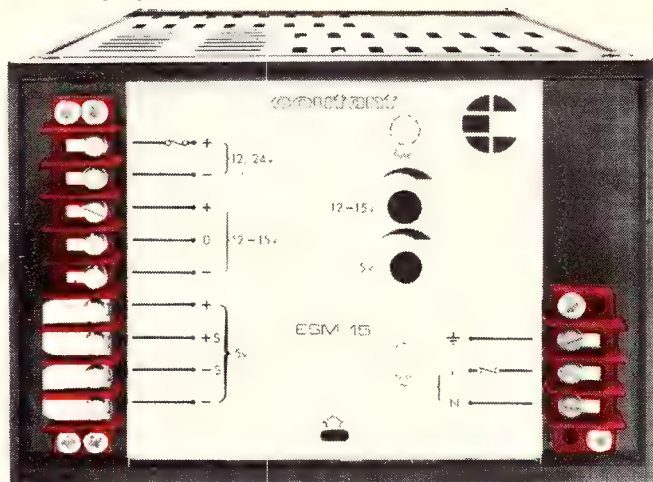
- The filtering capacitor is protected by the regulator itself. A low voltage rated capacitor can be used without the fear of overvoltage appearing across the capacitor.
- Power dissipation in the series transistor and in the

regulating Zener diode is greatly reduced since instead of a constant voltage appearing across the voltage and the Zener, a ripple voltage appears as shown in Fig. 2.

In the circuit of Fig. 2, the diode D is used to prevent the reverse breakdown of the series transistor owing to the higher leakage current of the regulating diode.

S G H Bhatta, Universal Electronics Ltd, PO Joka via Baruipur, 24 Parganas Pin Code No 743503, Calcutta, India.





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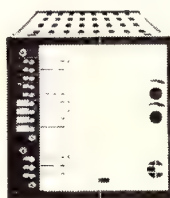
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SPECIFICATION

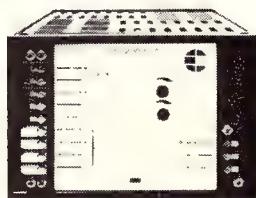
	5 Volt Line	± 12 Volt Line	24 Volt Line
Adjustment	4.75 to 5.25	± 12 to 15 Volt	None
Line Regulation	0.01%	0.06%+3mV	As input change
Load Regulation	0.03%+2mV	0.03%+15mV	20%
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Overvoltage Protection	6.5 Volt	—	—
Input Voltages	105, 115, 125, 220, 230, 240		



ESM3



ESM7



ESM 15.2

UNIT	5V	+12/15V	-12/15V	24V	Sizes mm			Weight
					H	L	W	
ESM3	3.0A	0.75A	0.75A	0.5A	125	80	240	4
ESM7	7.0A	1.2A	1.2A	1.0A	125	125	285	7
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Prizes will again be awarded for the best Applied Ideas published in *Electronic Engineering* during the year. Originality, suitability, elegance, adaptability and general usefulness will be taken into account.

Contributions should give a full but concise account of purpose, along with design criteria and an indication of performance.

Entries must be from named individuals and must not have appeared previously outside the origi-

nating establishment. A contributor's fee of £10 will be paid on publication.

Applied Ideas must be typed, using only one side of the paper, with double spacing and wide margins. Illustrations must be drawn clearly on separate sheets. They should be captioned, show component values and type numbers, and indicate test voltages and waveforms where appropriate. Entries should conform to the usual style of the journal.

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Competition 1976

Posters are available on the theme of applied ideas. The original drawing was produced by Heath Robinson for the first issue of *Electronic Engineering* way back in 1928. Drawn in Robinson's classical style, the cartoon depicts early ideas for the development of television at a time when exciting changes were occurring in the engineering industry.

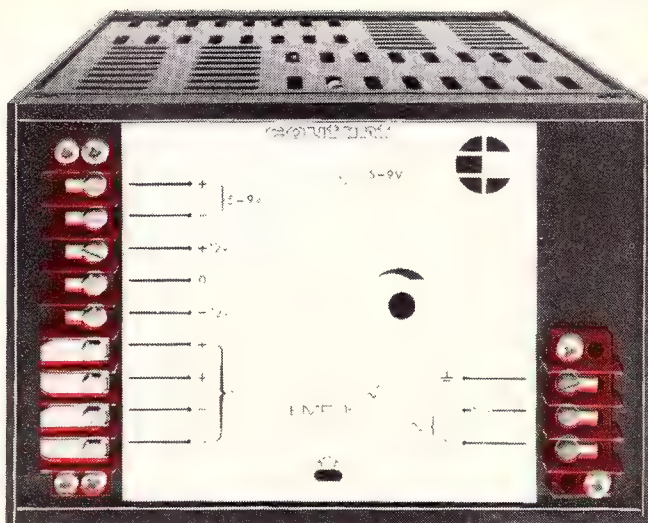
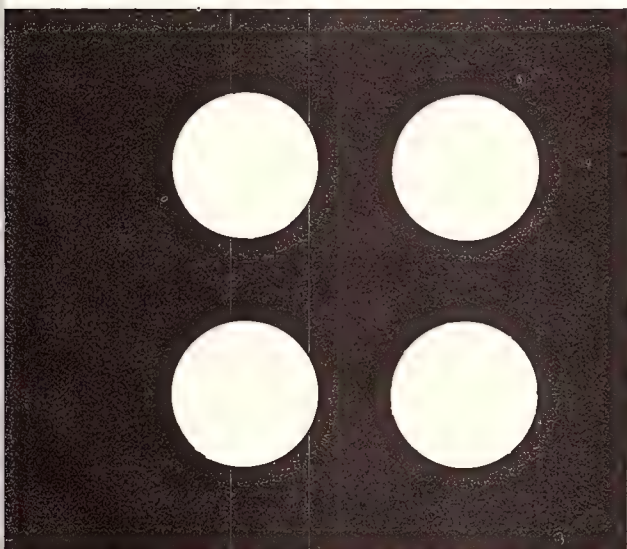
Robinson's ideas were of course very bizarre so it is not surprising that the innovations he illustrated during those early days never left the drawing board!

However *Electronic Engineering* has chosen to re-print several copies of this

Heath Robinson cartoon in order to stimulate the creation of design ideas and to provide a pleasant covering for any empty spaces on walls in the office, lab or even the home.

If you wish to obtain a set of posters (which comprises two large posters and two A4 reproductions of the cartoon) just send 25p in the form of a cheque or postal order (no cash please) made payable to Morgan Grampian Ltd. Post and package is included in the price. Requests for the poster should state name and address and be sent to the Editor at the address given on the facing page.

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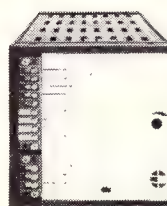
4 Output Rails	5 Volts	5 - 9v	$\pm 12V$
Voltage Adjustment	4.75-5.25	4.75-9.25	Fixed
Line Regulation	0.01%	0.06%+3mV	0.06%+3mV
Load Regulation	0.03%+2mV	0.03%+15mV	0.03%+15mV
Ripple	2mVp.p	5mVp.p	5mVp.p

Current:

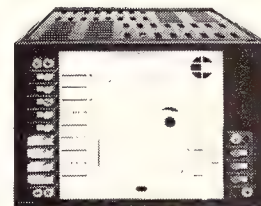
Unit	3.0A	0.5A	0.25
EMP3			
EMP7	7.0A	1.0A	0.25
EMP15	15.0A	2.0A	0.5A
Input Voltages	105, 115, 125, 220, 230, 240		



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Transistor	8 Lead Plastic DIP (Dual Channel)	6%-20%	1500	Colney
Transistor	TO-18 Metal Can	15%	1000	Tel. Bowmans Green 24522
Darlington	6 Lead Plastic DIP	100%-200%	1500	Kelso, Scotland
Diode	6 Lead Plastic DIP	15%	1500	Tel. Kelso 2366
Diode	TO-18 Metal Can	10%	1000	
Output Format	Package Types	Forward Blocking Voltages (VFXM)		Semiconductor Specialists (UK) Ltd.,
SCR	6 Lead Plastic DIP	200V-400V	1500	Yiewsley, West Drayton,
2 SCR's (Connected Anode to Cathode)	8 Lead Plastic DIP	200V	1500-2500	Middlesex Tel. 46415
Output Format	Package Types	Typical Bandwidth		West Lothian, Scotland
Logic Gate	8 Lead Plastic DIP	0.1MHz-1.0MHz	2000	Tel. Livingstone 31967
Output Format	Package Types	Collector Current (IC) @ (IF, VCE)		S.D.S. Components Ltd.
Transistor	Slotted Limit Switch	50µA @ 20mA, 10V		Portsmouth
		200µA @ 20mA, 10V		Tel. Portsmouth 65311.
Darlington	Slotted Limit Switch	1.6mA @ 50mA, 1V		
		2.0mA @ 16mA, 1V		
Darlington	Reflective Sensor Switch	50µA @ 50mA, 5V		

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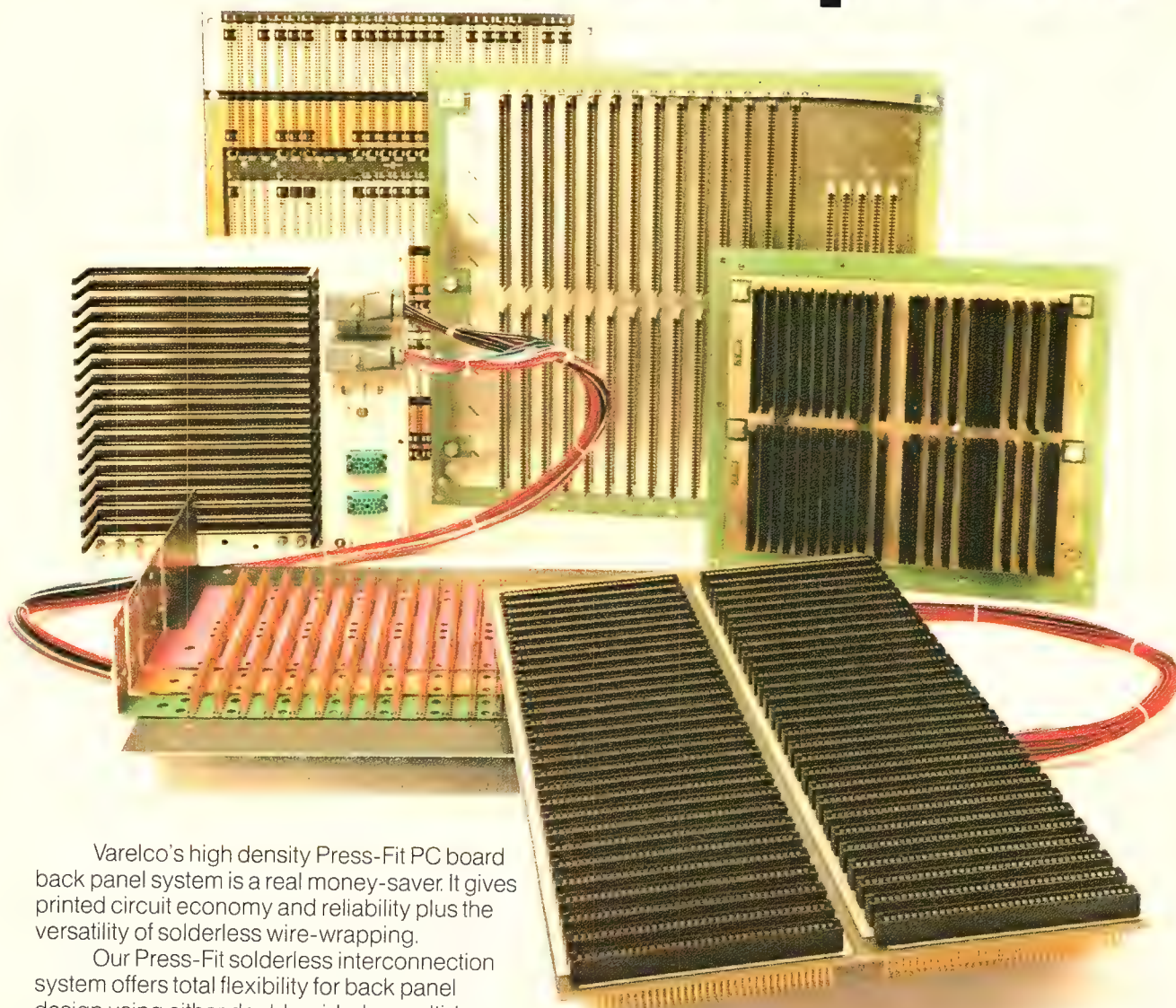
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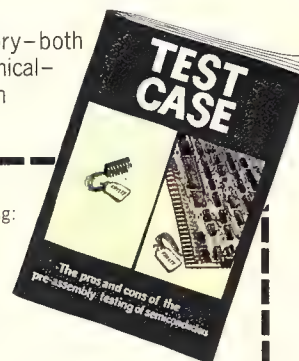
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Global Walsh function generators

Walsh functions are widely used for on-line discrete information processing applications but there are several types available. Using basic definitions and transformations, S. Tzafestas, G. Frangakis and T. Pimenidis show how circuits can be designed which provide any Walsh function type desired.

Walsh functions constitute a family of binary orthogonal functions that find important applications in many engineering fields such as two dimensional image transformation, sequency filtering, spectroscopy, multiplexing, speech synthesis and analysis. Recently the Walsh series approach has been used in optimal control problems and state space analysis. This seems to be a promising way of developing fast solutions to problems concerning optimal filtering and parameter estimation.

Although Walsh functions and transforms can be generated by software, generation by hardware is preferred in applications requiring special purpose computing for on-line processing.

Walsh function definitions

Walsh-Kacmarz ordering is a well known Walsh function definition. Walsh's 1923 definition defines the two valued orthogonal functions $f_k(x)$ for $k=2,3$, etc, as:

$$f_k(x) = \begin{cases} f_1(2x), & 0 \leq x < \frac{1}{2} \\ (-1)^k + f_1(2x-1), & \frac{1}{2} \leq x < 1 \end{cases} \quad (1)$$

This has initial values $f_0(x) = 1$, $0 \leq x < 1$, and $f_1(x) = +1$, $0 \leq x < \frac{1}{2}$, $f_1(x) = -1$, $\frac{1}{2} \leq x < 1$. Here $1 = [k/2]$ = integer part of $k/2$. The resultant Walsh-Kacmarz ordering of $f_k(x)$ has the property that the r th function, $f_r(x)$ has exactly r jumps on the interval $[0,1)$.

It can be seen that $f_k(x)$ takes only the value $+1$ or -1 on each of the 2^n equal subintervals $[m/2^n, (m+1)/2^n)$ for $m = 0$,

Mr Frangakis and Mr Pimenidis are associated with NRC Demokritos in Athens and Patras University respectively while Prof Tzafestas is involved with both organisations.

$1, \dots, 2^n - 1$ of the interval $[0,1)$, where n is the smallest integer such that $k < 2^n$. The n by n matrix $W_n(n = 2, 3, \dots)$ with elements on the k th row the values $+1$ and -1 of $f_k(x)$, $k < 2^n$, on all subintervals of $[0,1)$ is known as Walsh-Kacmarz matrix. For example,

$$W_3 = \begin{bmatrix} + & + & + & + & + & + & + & + \\ + & + & + & + & - & - & - & - \\ + & + & - & - & - & - & + & + \\ + & + & - & - & + & + & - & - \\ + & - & + & - & + & - & + & - \\ + & - & + & - & - & + & - & + \\ + & - & - & + & - & + & - & + \\ + & - & - & + & + & - & + & - \end{bmatrix} \begin{matrix} f_0 \\ f_1 \\ f_2 \\ f_3 \\ f_4 \\ f_5 \\ f_6 \\ f_7 \end{matrix} \quad (2)$$

where "+" and "-" represent $+1$ and -1 . Observe that W_3 (in general W_n) is symmetric, so that its columns are also Walsh functions ordered in the same way as the rows.

The second formula due to Kacmarz is:

$$f_N(k, x) = \exp \pi i \left\{ \sum_{m=0}^{N-1} (k_{N-m} \oplus k_{N-m-1}) x_m \right\}$$

where $\sum$ and $\oplus$ denote modulo-2 addition, $N = 2^n$ is the size of the Walsh matrix to which $w_N(k, x)$ belongs, and k_m, x_m are the digits of the binary expressions of k and x correspondingly.

The next ordering known as Walsh-Paley is based on the Rademacher functions $R_n(x)$ defined as:

$$R_n(x) = \begin{cases} +1, & 2k/2^n \leq x < (2k+1)/2^n \\ -1, & (2k+1)/2^n \leq x < (2k+2)/2^n \end{cases} \quad (n \geq 1) \quad (3)$$

Fig. 1: The structure of a global parallel Walsh generator.

for $0 \leq x < 1$, with $k = 0, 1, \dots, 2^n - 1$ and an initial function of $R_0(x) = 1$, $x \in [0,1)$. From equations 1 and 3, $R_n(x) = f_{2^{n-1}}(x)$. The Walsh-Paley functions $Y_k(x)$, $k < 2^n$ are defined by the products:

$$Y_k(x) = R_{k_m}^{k_m}(x) R_{k_{m-1}}^{k_{m-1}}(x) \dots R_{k_1}^{k_1}(x) \quad (4)$$

with $Y_0(x) = R_0(x)$, where $k_m, k_{m-1}, \dots, k_1$ are the digits in the dyadic expression of k ie, $k = k_m k_{m-1} \dots k_1$. The Walsh-Paley matrix $W'_n(n = 2, 3, \dots)$ is an n by n matrix with row elements the values of the functions $Y_k(x)$, $k < 2^n$.

$$W'_3 = \begin{bmatrix} + & + & + & + & + & + & + & + \\ + & + & + & + & - & - & - & - \\ + & + & - & - & - & - & + & + \\ + & + & - & - & + & + & - & - \\ + & - & + & - & + & - & + & - \\ + & - & + & - & - & + & - & + \\ + & - & - & + & - & + & - & + \\ + & - & - & + & + & - & + & - \end{bmatrix} \begin{matrix} Y_0 \\ Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \\ Y_5 \\ Y_6 \\ Y_7 \end{matrix} \quad (5)$$

A compact formula which defines the Walsh-Paley functions is

$$Z_N(k, x) = \exp \left\{ \pi i \sum_{m=0}^{N-1} k_m x_m \right\}$$

For Walsh-pattern product ordering let p be a pattern of $+1$ s and -1 s, representing the values of a Walsh function, and define the basic patterns as $\bar{0} = 11, \bar{1} = 1-1$, together with the pattern products $\bar{0}.p = pp$ (the pattern p followed by itself) and $\bar{1}.p = p-p$ (p followed by the pattern which has the negations of the elements in p). If $p = \bar{1} = 1-1$, then $p' = \bar{0}.p = 1-1-1-1$ and $p'' = 1p' = 1-1-1-1-1-1-1-1$. The first 2^n Walsh functions can be

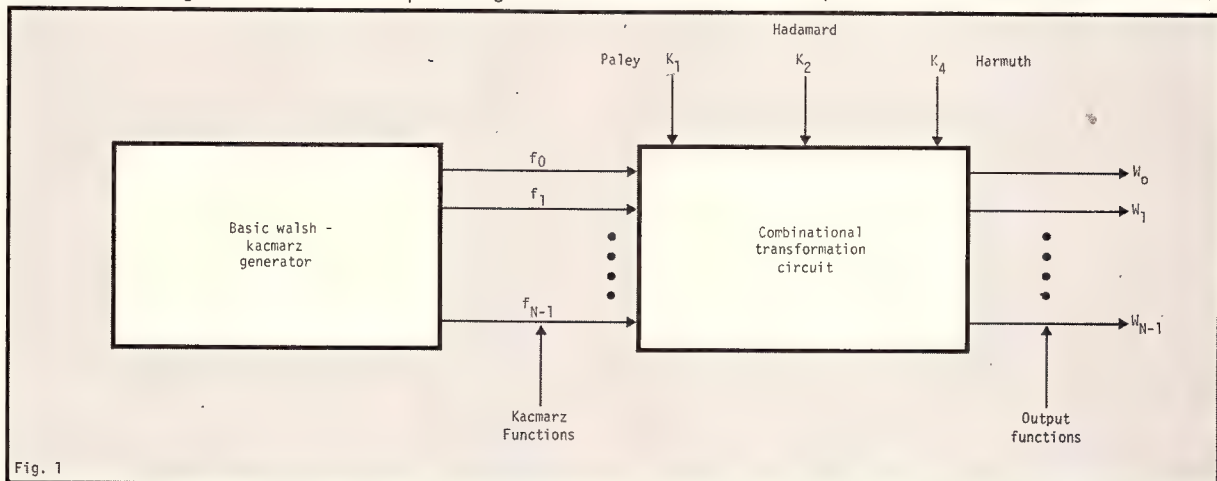


Fig. 1

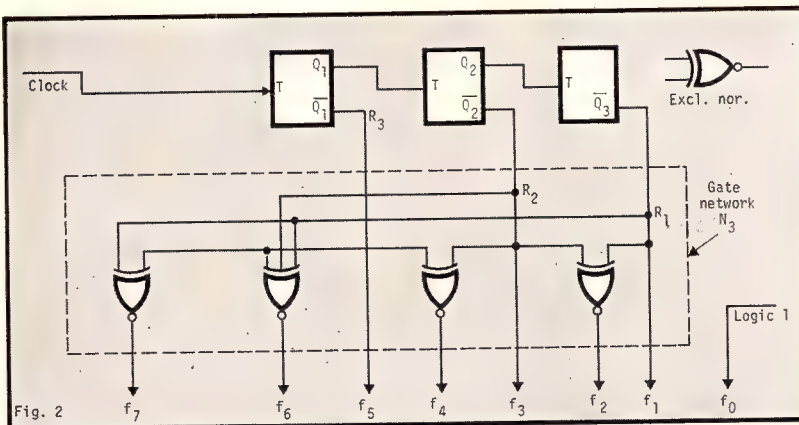


Fig. 2

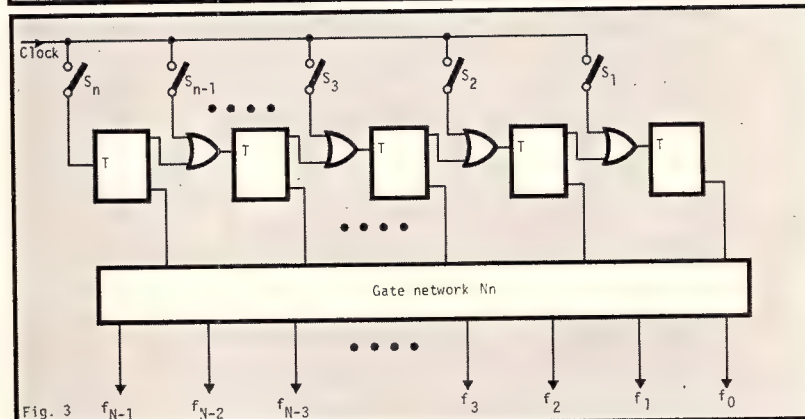


Fig. 3

obtained by forming all possible products of n factors, each one being a basic pattern. This implies that a Walsh function can be defined as a basic pattern or the pattern product of a Walsh function and a basic pattern. The Walsh-pattern product ordering matrix is denoted by $\tilde{W}_n$. The matrix $\tilde{W}_3$ is:

$$\tilde{W}_3 = \begin{bmatrix} + & + & + & + & + & + & + & + \\ + & + & - & - & + & + & - & - \\ + & - & + & - & + & - & + & - \\ + & - & - & + & - & + & - & + \\ + & + & + & + & - & - & - & - \\ + & + & - & - & - & - & + & + \\ + & - & + & - & - & + & - & + \\ + & - & - & + & - & + & + & - \end{bmatrix} \quad (6)$$

Hadamard matrices, the fourth definition so far are denoted by H_N where their order N is equal to $N \equiv 0 \pmod{4}$. The simplest Hadamard matrix construction is obtained for $N = 2^n$ ($n = 0, 1, \dots$). In this case, the matrix

$$G = \begin{bmatrix} H_N & H_N \\ H_N & -H_N \end{bmatrix}$$

is a Hadamard matrix of order $2N$. The rows and columns of a Hadamard matrix are Walsh functions denoted by $h_k(x)$ where the ordering k is called Walsh-Hadamard ordering. The matrix H_8 is given by:

Fig. 2: Walsh-Kacmarz generator.
Fig. 3: Walsh-Kacmarz for $N=2^n$.
Fig. 4: Global parallel generator.

$$H_8 = \begin{bmatrix} + & + & + & + & + & + & + & + \\ + & - & - & - & + & + & + & - \\ + & + & - & - & + & - & + & - \\ + & - & + & - & + & - & - & + \\ + & + & + & - & - & + & - & + \\ + & - & - & + & - & - & + & - \\ + & + & - & - & - & + & - & + \\ + & - & + & - & - & + & + & - \end{bmatrix} \begin{matrix} h_0 \\ h_1 \\ h_2 \\ h_3 \\ h_4 \\ h_5 \\ h_6 \\ h_7 \end{matrix} \quad (7)$$

From equations 6 and 7, $H_8 = W_8$. In general $H_N = W_N$ for $N = 2^n$.

The Walsh-Harmuth functions $walk_k(x)$, $k = 0, 1, 2, 3$, are defined for x in the interval $[-\frac{1}{2}, \frac{1}{2}]$ as:

$$walk_{2j+p}(x) = (-1)^{[j/2]+p} \left\{ wal_j\left(2x + \frac{1}{2}\right) + (-1)^j + p wal_j\left(2x - \frac{1}{2}\right) \right\} \quad (8)$$

where again $[a]$ denotes the integral part of a , and p takes the values 0 or +1. When $p = 0$ the even functions $cal_k(x) = wal_{2k}(x)$ are obtained and when $p = +1$ the odd functions $sal_k(x) = wal_{2k+1}(x)$ appear. Some properties of the Walsh-Harmuth functions are:

$$\begin{aligned} cal_k(x) cal_k(x) &= cal_k(x) \\ sal_k(x) cal_k(x) &= sal_k(x) \\ sal_k(x) sal_k(x) &= cal_k(x) \end{aligned}$$

The matrices $\tilde{W}_n$ associated with $walk_k(x)$ are called Walsh-Harmuth matrices. The matrix $\tilde{W}_3$ is:

$$\tilde{W}_3 = \begin{bmatrix} + & + & + & + & + & + & + & + \\ + & - & - & - & + & + & + & - \\ + & + & - & - & + & - & + & - \\ + & - & + & - & + & - & - & + \\ + & + & + & + & - & - & - & - \\ + & + & - & - & - & - & + & + \\ + & - & + & - & - & + & - & + \\ + & - & - & + & - & + & + & - \end{bmatrix} \begin{matrix} cal_0 = wal_0 \\ sal_1 = wal_1 \\ cal_1 = wal_2 \\ sal_2 = wal_3 \\ cal_2 = wal_4 \\ sal_3 = wal_5 \\ cal_3 = wal_6 \\ sal_4 = wal_7 \end{matrix} \quad (9)$$

The final ordering discussed is based on a Rademacher function in the interval $[-\frac{1}{2}, \frac{1}{2}]$, denoted by $R_n(1, x)$, which is a string of -1 s and $+1$ s. Associated with $R_n(1, x)$ are new Walsh-Paley functions defined over $[-\frac{1}{2}, \frac{1}{2}]$ and constructed again by a product similar to that in

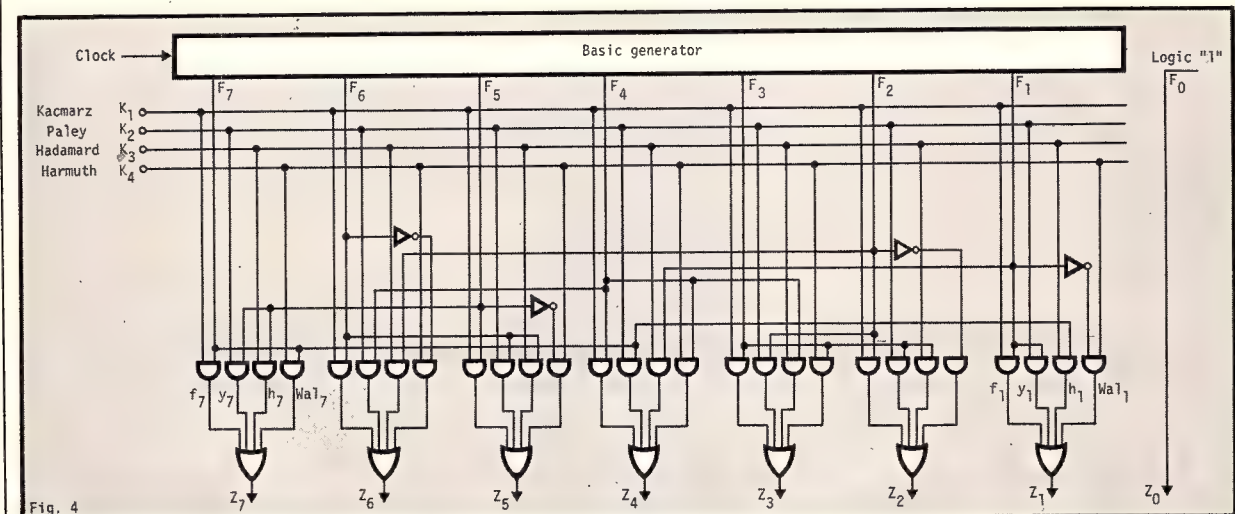


Fig. 4

equation 4. The only difference between the Walsh-Paley functions based the interval on $[0,1)$ and on $[-\frac{1}{2},\frac{1}{2})$ is that they are inverse to each other. Hence if W'_n is the Walsh-Paley matrix on $[-\frac{1}{2},\frac{1}{2})$ then $W''_n = -W'_n = (n = 2, 3, \dots)$, where W'_n is given by equation five.

Walsh matrix transformation

A given N by N Walsh matrix can be converted to another N by N matrix by an appropriate transformation matrix T . Since all Walsh matrices of a given size contain the same rows in different order, the transformation matrices contain only a single one at each row, the remaining elements of the row being zero. Consider the transformation $W_3 T_3 = W'_3$. From equations 2 and 5:

$$T_3 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} A_2 & 0 \\ 0 & P_2 A_2 \end{bmatrix} \quad (10)$$

where P_2 is the matrix which interchanges the rows of A_2 . A one in the (i,j) position of T_3 implies that the j th row $((j-1)$ th function) of W'_3 is identical to the i th row $((i-1)$ th function) of W_3 . This observation is true in all cases where the interval of x does not change. It can be used as a rule for writing down the transformation matrix between two Walsh matrices of the same size. So, from equations 2 and 6 for $W_3 T_3 = W'_3 = H_3$ the transformation is:

$$\bar{T}_3 = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} e_1 & e_0 & e_3 & e_0 & e_2 & e_0 & e_4 & e_0 \\ e_0 & e_1 & e_0 & e_3 & e_0 & e_2 & e_0 & e_4 \end{bmatrix} \quad (11)$$

where e_i ($i = 0, 1, 2, 3, 4$) are 4-dimensional column vectors as shown in equation 11.

The transformation $\bar{T}_3$ in $W_3 \bar{T}_3 = \bar{W}_3$ from equation 9 (where I_2 is found to be the 2 by 2 unit matrix) is found to be:

$$T_3 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & & & & & & & \\ & -I_2 & & & & & & \\ & & -I_2 & & & & & \\ & & & I_2 & & & & \\ & & & & I_2 & & & \\ & & & & & I_2 & & \\ & & & & & & I_2 & \\ & & & & & & & I_2 \end{bmatrix} \quad (12)$$

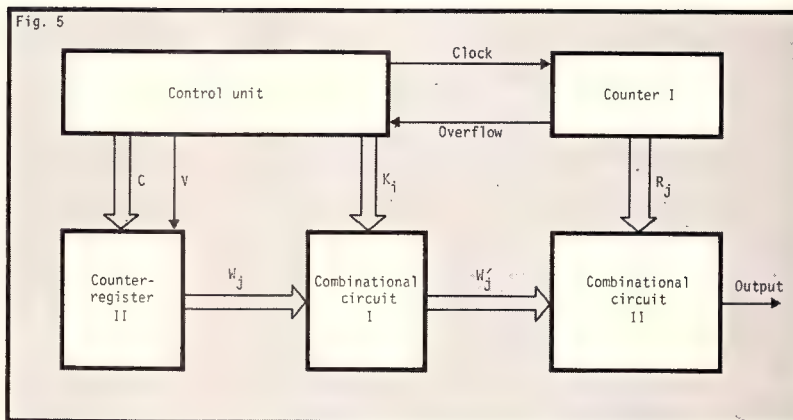


Fig. 5. The structure of a global sequential Walsh Generator.

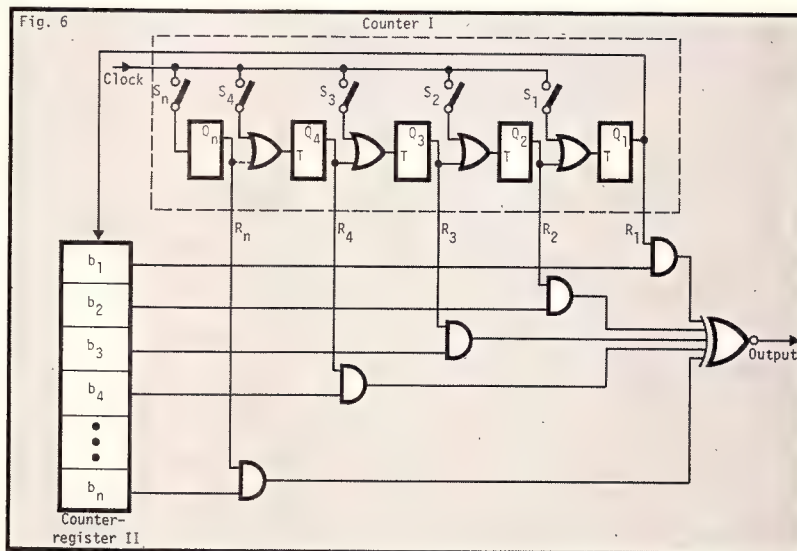
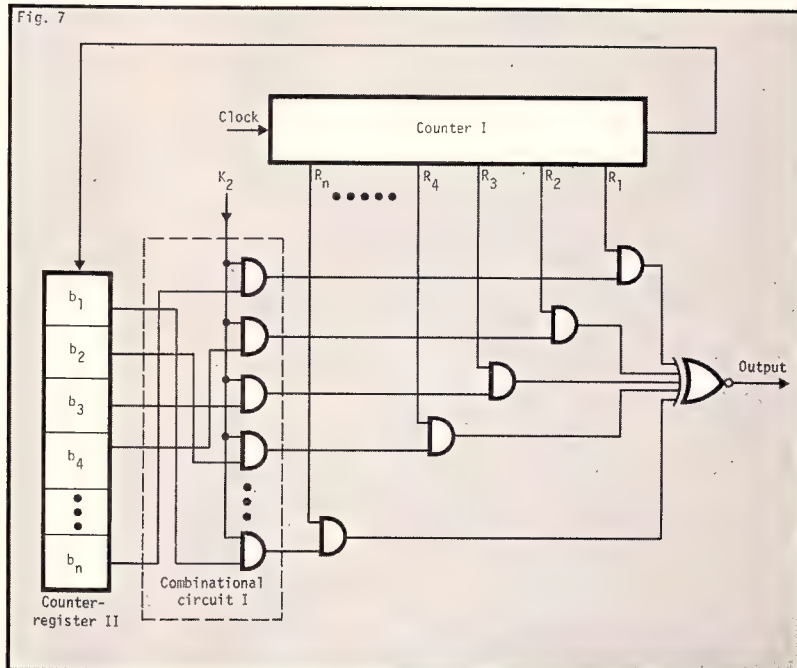


Fig. 6. A sequential Walsh-Paley generator.

Fig. 7. A sequential Walsh-Hadamard generator.



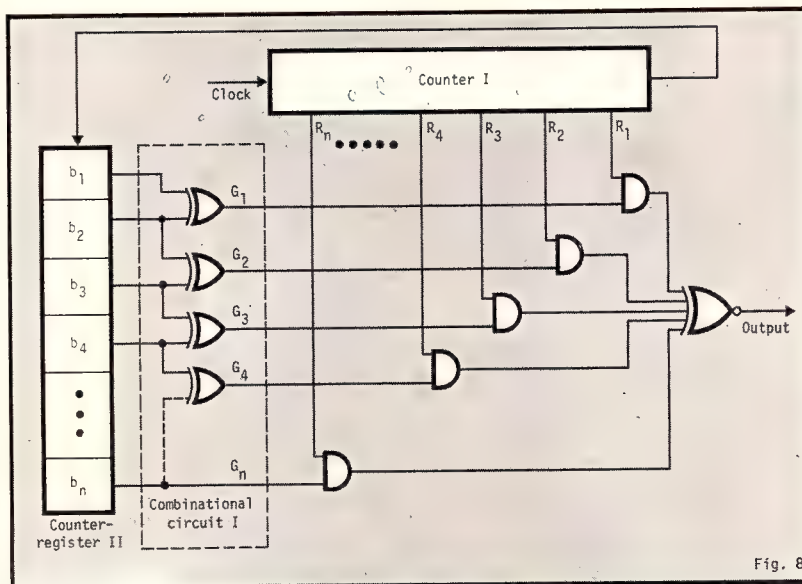


Fig. 8. A sequential Walsh-Kacmarz generator.

Sign inversions occur in this transformation because there is a shift of the interval $[0,1)$ to $[-\frac{1}{2}, \frac{1}{2})$. Equations 10-12 give the transformation matrices of size 8 by 8, but they can be generalized for any matrix size. Denoting T'_s as

$$T'_s = \begin{bmatrix} A_s & 0 \\ 0 & P_s A_s \end{bmatrix} \text{ we find by induction}$$

that

$$T'_{q+1} = \begin{bmatrix} A_{q+1} & 0 \\ 0 & P_{q+1} A_{q+1} \end{bmatrix},$$

$$A_{q+1} = \begin{bmatrix} A_q & 0 \\ 0 & P_q A_q \end{bmatrix},$$

$$P_{q+1} A_{q+1} = \begin{bmatrix} 0 & A_q \\ P_q A_q & 0 \end{bmatrix}$$

for $q = 2, 3$, etc. Concerning $\tilde{T}_2$ and $\tilde{T}_4$ we have $\tilde{T}_2 = [e_1 e_3 e_5 e_7]$ and

$$T = \begin{bmatrix} e_1 e_0 e_0 e_0 e_3 e_0 e_0 e_0 e_2 e_0 e_0 e_0 e_4 e_0 e_0 e_0 \\ e_0 e_0 e_1 e_0 e_0 e_0 e_3 e_0 e_0 e_0 e_2 e_0 e_0 e_0 e_4 e_0 \\ e_0 e_0 e_1 e_0 e_0 e_0 e_3 e_0 e_0 e_0 e_2 e_0 e_0 e_0 e_4 e_0 \\ e_0 e_0 e_1 e_0 e_0 e_0 e_3 e_0 e_0 e_0 e_2 e_0 e_0 e_0 e_4 e_0 \end{bmatrix}$$

from which the rule of augmenting the size of T_n is obvious.

From equation 12, $\tilde{T}_s$ is a diagonal matrix involving $-I_2$ and I_2 alternately as many times as required. The forms of $\tilde{T}_s$ can be established by inspecting the definition equations 1 and 8.

Parallel generation

Walsh function generation may be parallel or sequential. In parallel generation all elements of each column of a Walsh matrix are simultaneously generated, whereas in the sequential type only one element of each column is generated each time.

The global parallel Walsh function

generator has the general structure of Fig. 1. The basic generator section is designed to generate the Walsh-Kacmarz matrix and other Walsh matrices are produced by feeding the Walsh-Kacmarz outputs to combinational circuits and controlling the lines K_1, K_2 , etc. To generate the matrix W_3 from equation 2, the logic code $(+) \rightarrow 1$ and $(-) \rightarrow 0$ is used. One way to generate the Walsh-Kacmarz function is by modulo addition of the Rademacher functions R_j . These coincide with the bcd code 8-4-2-1 and can be generated by a bcd counter. W_3 is generated using a 3-bit counter to produce R_1, R_2 and R_3 and construct $f_i (i = 0, 1, \dots, 7)$ from table 1 where $R_3 R_2 R_1$ is defined according to the Gray code.

Table 1

k	$R_3 R_2 R_1$	f_k
0	0 0 0	1
1	0 0 1	R_1
2	0 1 1	$R_1 \oplus R_2$
3	0 1 0	R_3
4	1 1 0	$R_2 \oplus R_3$
5	1 1 1	$R_1 \oplus R_2 \oplus R_3$
6	1 0 1	$R_1 \oplus R_3$
7	1 0 0	R_3

Using Table 1 the basic Walsh-Kacmarz parallel generator has the circuit shown in Fig. 2. The counter is an asynchronous ripple-through type but at high speed a synchronous counter may be needed. The circuit is expandable to any order n as shown in Fig. 3 by setting switch S_1 to the on position.

The detailed circuit of the global parallel generator which provides the matrices W_3 (Kacmarz), W'_3 (Paley), $\tilde{W}_3$ (pattern product), H_3 (Hadamard), $\tilde{W}_3$ (Harmuth), and W''_3 (Paley for $-\frac{1}{2} < x < \frac{1}{2}$) is based on the corresponding transformation matrices T'_s (equ. 10), $\tilde{T}_s$ (equ. 11), $\tilde{T}_s$ (equ. 12) and $T''_s = -I_3$ is shown in Fig. 4. When a control line K_1 is set at logic one at the outputs $Z_i (i = 0, 1, \dots)$ the Walsh functions are obtained in the corresponding ordering. The Walsh functions of all types can be produced by setting all control lines at one and taking the outputs from the corresponding and gates.

Sequential generation

The block diagram of the global sequential Walsh function generator has the structure of Fig. 5. The counter I generates the Rademacher functions $R_j(x)$. The number of the Walsh function row to be produced is written into Counter-Register II in binary form. Channel C, the control unit (channel K_1) and the combinational circuit determines the type of functions to be generated. The combinational circuit realizes the Walsh function transformations in serial form. An entire Walsh matrix can be generated by feeding the overflow of the counter back to the control unit and successively

Fig. 9. A sequential Walsh-Harmuth generator.

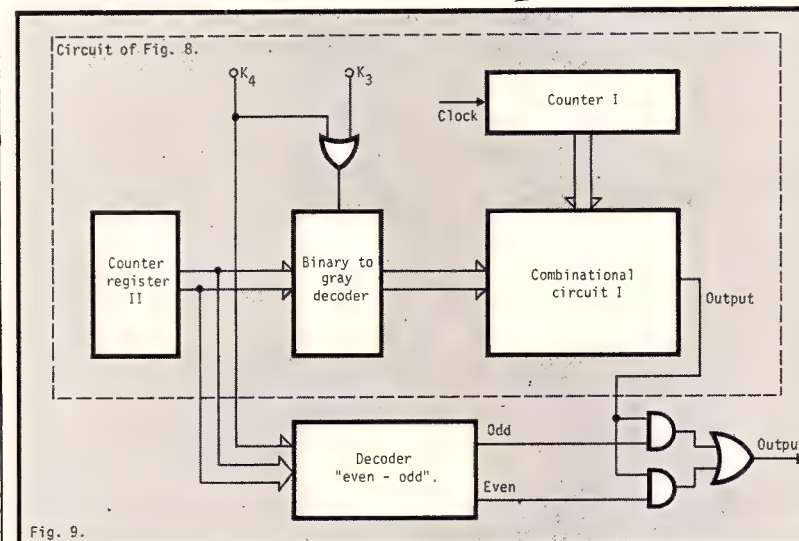


Fig. 10. A combinational circuit for a 8 x 8 global sequential Walsh function generator.

increasing the content of the register-counter II (line V). The combinational circuit performs the required exclusive *nor* of the quantities $R_j W'_j$.

Walsh-Paley functions are obtained from the circuit of Fig. 6. This has the structure of Fig. 5 with the combinational circuit being the direct connection of w_j and w'_j . To generate the Walsh-Paley matrix W'_3 , only three bits of the register-counter II, bits $b_1 b_2 b_3$ are used and switch S_3 is closed.

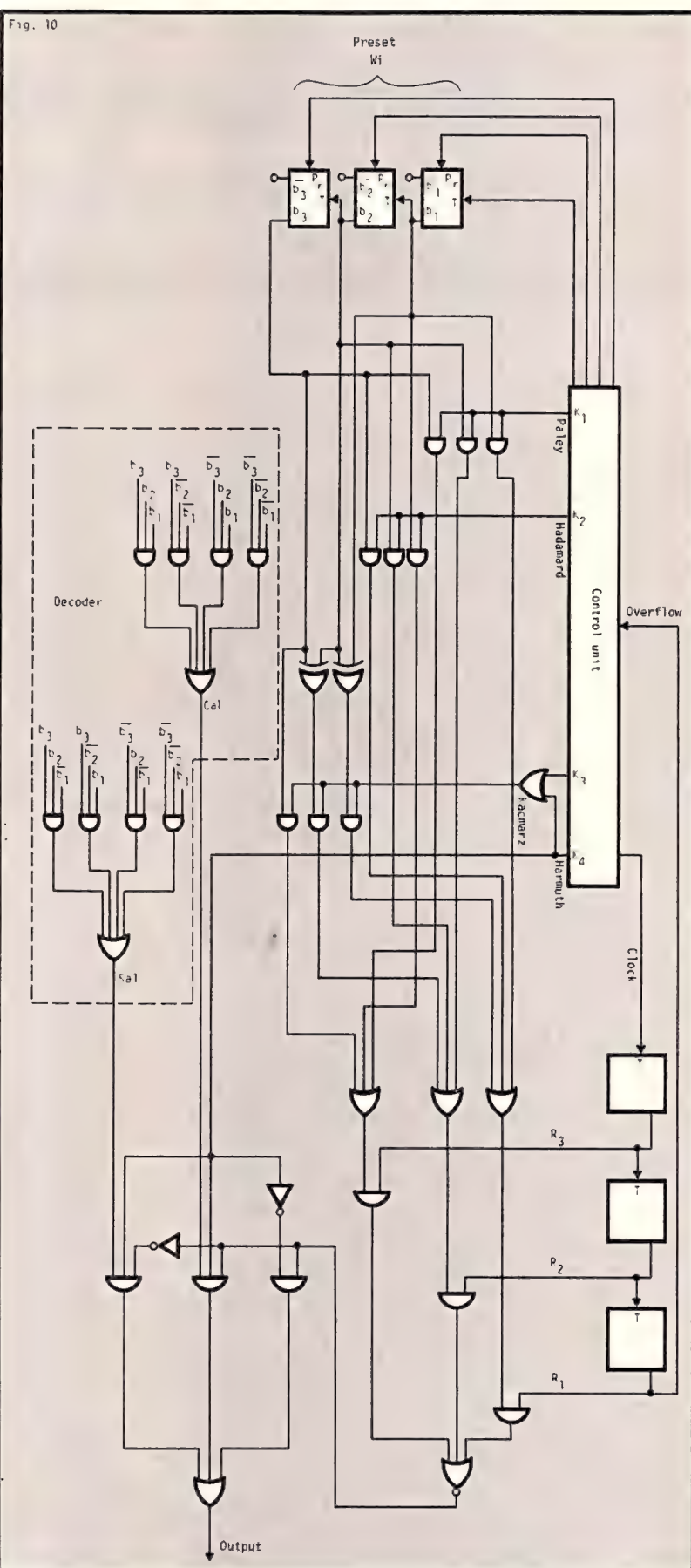
The Walsh-Hadamard generation circuit of Fig. 7 is the same as Fig. 6 except that the content of the register-counter II is fed into *and* gates in reverse order. This is achieved with the aid of the combinational circuit (within the broken line) which interchanges the lsb with the msb to generate the Walsh-Kacmarz matrix utilised the circuit of Fig. 8. Here the combinational circuit is a decoder to Gray code having the logic equation $G_1 = B_1 \oplus B_{1+1}$.

Finally the Walsh-Harmuth matrix has the same circuit as Fig. 8 but provision is made to obtain the functions "cal" and "sal" at the output. This can be achieved by connecting a decoder at the output of the register-counter which recognizes the even (cal) and odd (sal) functions and controls the output of Fig. 8 as shown in Fig. 9. Alternatively the bit b_0 of register-counter is set to zero, the number j is written in positions $b_1 b_2 \dots b_n$, and the content of the register-counter shifted by one position to the right. This gives $cal_j(x)$. To obtain $sal_j(x)$ set $b_0 = 1$, and write the number $j-1$ in positions $b_1 b_2 b_3 \dots b_n$. The complete circuit of a 8 by 8 global sequential Walsh function generator combines the circuits of Figs. 6-9 as shown in Fig. 10.

All existing Walsh function definitions have been directly compared and transformed. Global parallel and global sequential generators have been designed to provide all Walsh function types either separately or simultaneously. Hopefully any confusion which may arise by looking at the diverse literature available on Walsh functions has been eliminated.

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Substrate materials are critical for microwave stripline design

In many areas of electronics material considerations are unimportant but in the realms of microwave applications, circuit designers have to be aware of the limitations the material used imposes on the design. *Elaine Williams* looks at the effect of materials on stripline design in the light of developments of substrate manufacture.

The increasing interest in the development of optical communications will put more pressure on microwave systems engineers to produce smaller and more flexible equipment. One area in which this size reduction has already taken place has been in the replacement of heavy hollow pipe waveguides and coaxial components with lightweight flat pack circuitry—generally known as stripline—for a variety of applications.

Such applications have been in the design of such components as filters, directional couplers, microwave switches and attenuators, power dividers and phase shifters. There has even been investigations carried out into the use of stripline in high speed computer circuits.

The advantage of using stripline in microwave applications is enhanced by the fact that the behaviour of stripline can be determined by a slight adaptation of the existing theory. For practical purposes the stripline is considered to be a flattened form of coaxial cable and as with coaxial cable it is particularly versatile component with which to work.

Basically stripline consists of a pattern of conductive strips which are etched from a copper laminate. The stripline forms not only the connections but also the critical passive components such as capacitors, inductors and filters. The values of these circuit parameters have a great dependence on the physical and dimensional properties of the dielectric used in the laminate.

One of the greatest problems for the circuit designer is the variability of the dielectric properties from one batch of laminates to another. It is this area where the material supplier should be more sensitive to the needs of the circuit designer to supply the necessary balance of properties.

Microwave designers working in the stripline field must then be aware of the physical limitations of the product being used and must compensate for the range of characteristics the stripline may exhibit. However stripline circuits have some useful properties as compared with conventional systems. The shielded open faced form with a ceramic substrate—which is known as

microstrip—can easily incorporate solid state devices.

Stripline circuits normally comprise a narrow flat strip of copper sandwiched between two outer layers of dielectric. The outer surfaces are then etched with copper foil. For the most common single registration type of stripline the circuit is photoetched on one side of the copper clad laminate. The circuit is then laid against the insulating face of a single clad board. The sandwich so formed is held together either by clamping, using eyelets or by thermocompression bonding. The connections are made either at the edge of the package or directly through one side.

The performance of the circuit is highly dependant on the dielectric constant and thickness of the substrate material. The thickness affects the characteristic impedance of the circuit. The consequence of this is that the characteristic impedance cannot be controlled any closer than the manufacturing spread in dielectric thickness. For example, the tolerance of a 31,25 mils laminate is ± 5 mils, so that the percent variation possible is 32 percent. The characteristic impedance of a given width strip will also vary over roughly this range. Although for laboratory work the linewidth can be adjusted for each board it becomes an intolerable situation in a production environment.

The degree to which the dielectric constant and thickness becomes important varies with the application. The design of antennas for example requires a close control on the dielectric constant, because of the need for an accurate control on pulse delay. The dielectric constant controls the propagation time but the circuits can often tolerate a variation if there is adequate power available to compensate for any mismatches which may occur in the circuit.

In the microwave circuit area all the parameters require fine control. The resonant frequency of the strip and the phase relationships of signals following different paths all depend on the dielectric constant. However the characteristic impedance and all other impedances are directly related to the ratio of strip width to dielectric thick-

ness (and only on the square root of the dielectric constant).

So the dielectric constitutes an important part of the laminate as the properties it exhibits hold the key to the correct design of the circuits. The most used dielectrics are irradiated polyolefin, crosslinked polystyrene, ceramic and glass reinforced ptfe. In fact 3M has developed a ceramic powder filled tfe resin which can be substituted for alumina in both L band and X band applications.

Substrates can be very sensitive to not only changes in parameters such as pressure and temperature but to variations in environmental such as moisture. Also the amount of sensitivity exhibited by stripline circuits can be affected by the type of package such as the bonded or eyeletted types.

In fact it has been shown that direct bonding of the stripline interface can make the circuit largely insensitive to moisture, thermocycling and vibration. Direct bonding appears to produce a stripline circuit which can meet the initial performance specifications and maintain them under various adverse conditions imposed during storage and operation.

Most materials are unfortunately endowed with both debits and credits. The first two materials mentioned have low losses but have a relatively low operating temperature range of around 100°C. For circuit applications which require thermal cycling the dimensional stability of polyolefin circuits become extremely suspect while ceramics are suitable for unshielded microstrip application but are not desirable for stripline circuits which require large areas. Also ceramics are not easily machined, bent or clamped. Polyphenylene oxide and ptfe laminates have high thermal resistance and good dimensional stability at the expense of having a relatively low dielectric constant.

Materials such as alumina although being a difficult material to work with, has a high dielectric constant. This constant affects the size and radiation loss of the circuit and the greater the value of the constant the smaller the circuit size may be. Alumina ceramics can have a dielectric of the order of nine which reduces the wavelength in the substrate to one third of the free space

value. This can be determined from the relationship $\lambda = \lambda_0/\sqrt{K}$ (where λ is the stripline wavelength, λ_0 is the freespace wavelength and K is the dielectric constant).

This wavelength compression has another advantage besides reducing the circuit size. Since the wavelength is much shorter than the free space value, little radiation of energy takes place even from a microstrip package in which the circuit has only one ground plane and is open to the air. Also because free space is available above a microstrip package small solid state devices can be introduced into the circuit without having to provide any extra cavities in the dielectric to accommodate them.

Any new materials should then combine the flexibility and large size capability of the glass/tfe laminates and the high dielectric constant of alumina. In fact 3M claim that its substrate (trade named Epsilon 10) goes a long way to fulfilling these requirements. The material has a dielectric constant of around 10.3 which is comparable with alumina but it is easily cut and is capable of large sheet size.

The company has tried to eliminate the customary bonding film for adhering the copper foil to the substrate. Usually the bonding film is an unfilled thermoplastic and these tend to soften at soldering temperatures and cause dielectric discontinuities. Since the copper in Epsilon 10 is directly bonded to the substrate the bond is essentially unaffected by heat, moisture vibration and the detrimental effects of thermocycling.

The ability to work materials is an important factor since in many applications the circuit is required to be bent or cut into various configurations such as in wrap around antennas or phased array antennas. Epsilon 10 for example can be cut with a shear or razor blade and serves as a useful prototype material where ceramic will eventually be required. It can retain its curvature to which it is formed much better than tfe/glass so that extra stressing of the copper is not required.

The choice of method for making connections to such materials obviously depends on whether the substrate is ceramic or glass/tfe based and some conventional methods may become inapplicable if the substrate materials is too soft.

In thermocompression bonding the hot stage (around 300°C) often softens the substrate too much and it may deform. Pulse or ultrasonic bonding would be more suitable for non-ceramic based materials to prevent loss in circuit performance.

When actually etching out the copper to form the circuit, care has to be taken to ensure that the process does not have any detrimental effects on the

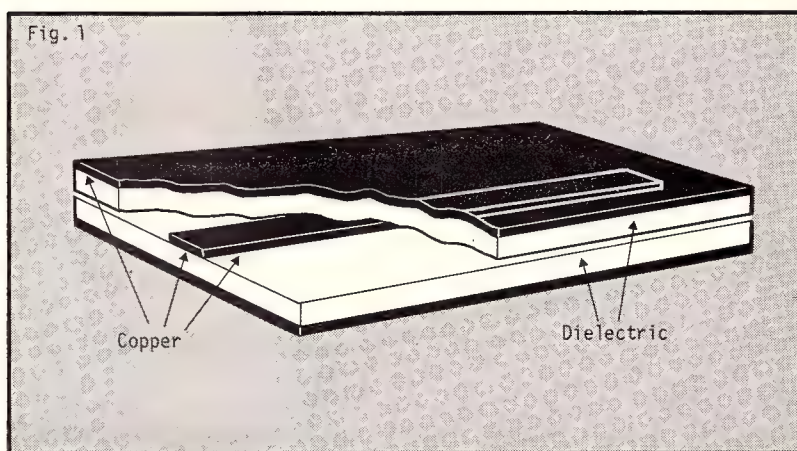


Fig. 1: This cutaway view of a simple stripline shows the flat strip of copper sandwiched between two outer layers of dielectric.

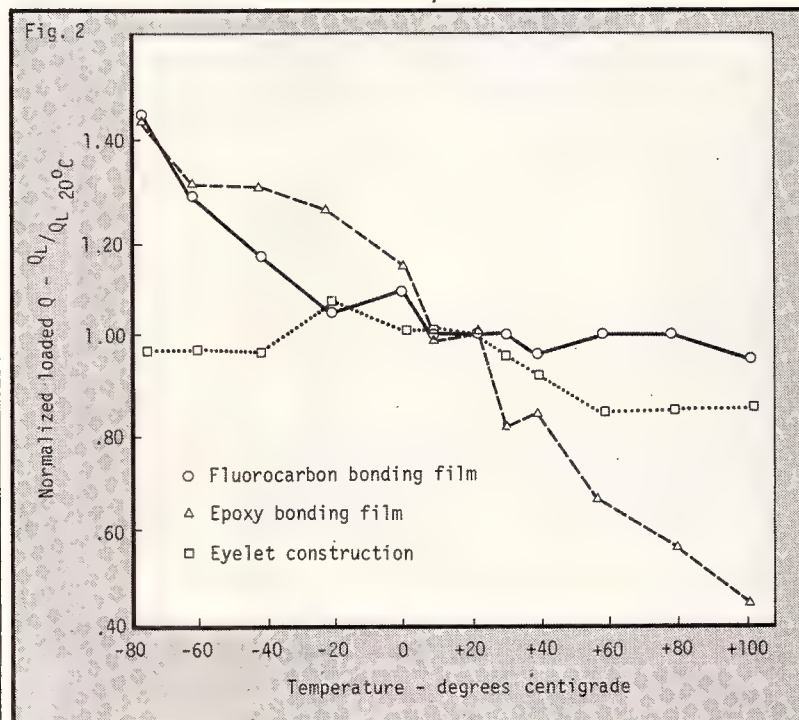
performance of the circuits once formed. Shrinkage may occur during etching or there may be increased line attenuation due to moisture absorbed during processing. In many cases this can be negligible when dealing with low frequencies of operation.

Taking Epsilon 10 as an example it is recommended that the etched circuit should be baked for two hours at 180°C to 200°C if the circuit is to operate above 2 GHz. If processing chemical remains when the water is removed by baking the dielectric may become sensitive to re-absorption of water. Retained chemicals could have an adverse effect on the copper or additional metallization. Also if any acidity is present when the copper is rinsed there may be a possibility of reprecip-

tating the copper from the absorbed etching solution.

Every material has its applications and limitations. The substrate mentioned has been developed specifically as a microwave substrate for application from one to 10 GHz. It is a low cost material compared with conventional materials and is ideal in prototyping applications and for fabricating microstrips such as power dividers and matching networks. If microwave circuitry is to become more flexible the industry needs more materials such as Epsilon 10 which can provide several advantages under certain conditions, of both ceramic and glass/tfe type substrates while also providing a benefit in cost reductions to the circuit designer and fabricator.

Fig. 2: This shows the comparative sensitivity of the normalised resonator Q for three constructions to temperature variation.





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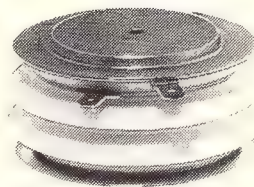


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Radar detection in log-normal clutter examined statistically

Radar detection in clutter has been viewed as exploiting the difference in Doppler spectral characteristics between target and clutter writes **D C Schleher**. This article examines radar detection from a statistical viewpoint.

Historically, radar detection in clutter has been viewed as a problem of exploiting the difference in Doppler spectral characteristics between the target and the clutter. However, in many practical situations the target and clutter spectrums overlap, making Doppler filtering ineffective. The problem then becomes a statistical detection problem whereby the clutter becomes an interfering background.

The amplitude probability density function and the power spectral density are important in this type of problem. A clutter model assumed by early workers was that of many independent randomly phased scatterers. It is well known that envelope detection of this process produces a Rayleigh amplitude distribution. However, measurements on real clutter reveal a substantial departure from the Rayleigh statistics. A log-normal type of distribution in many cases fits the experimental data. Valenzuela, who analyzed the mechanism for generating non-Rayleigh type distributions for sea clutter, conjectured that the amplitude probability distribution of sea clutter could be described by distributions that vary from the Rayleigh to the log-normal. This conjecture brackets most known experimentally determined clutter distributions, and radar receivers

designed on this basis would accommodate a very broad class of clutter characteristics.

The statistical detection of radar targets in a clutter background can be approached using a Marcum Swerling approach. This approach assumes that independent samples of clutter and target-plus-clutter are available, and applies to situations where scan-to-scan integration techniques are utilized. The advantage of this approach is that it allows a direct comparison between the detection performance in Rayleigh and log-normal clutter.

The performance in Rayleigh distributed clutter is readily obtained by noting that envelope detected Rayleigh distributed clutter produces the same probability density function as envelope detected receiver noise. Therefore, the Marcum-Swerling performance curves can be directly applied to the problem. In addition, the performance of several suboptimum receivers in Rayleigh clutters can be inferred from previous analysis of the logarithmic detector, binary detector, and median detector.

The principal contribution of this article is the determination of the optimum performance obtainable in log-normal clutter and the identification of

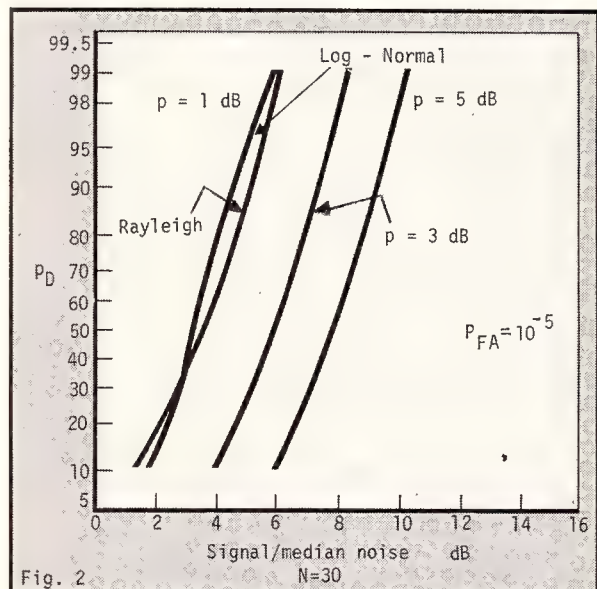
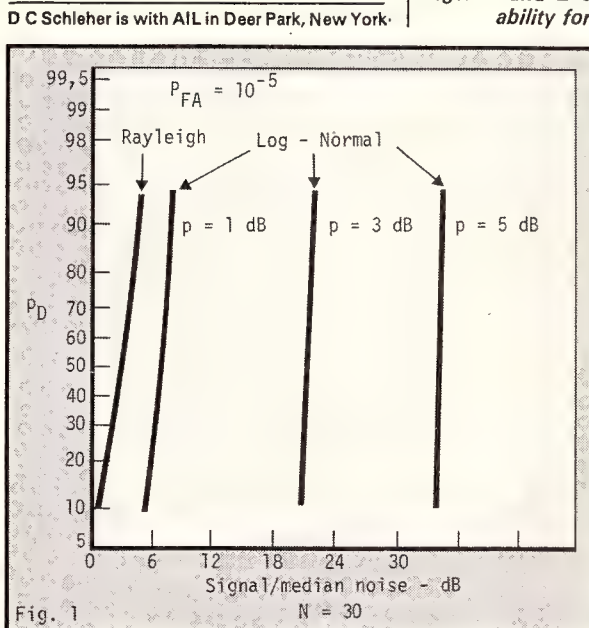
practical receivers that approach this performance. This advances the work of Trunk and George who analyzed both the linear receiver (linear envelope detector with linear integrator) and median detector but made no attempt to assess their optimality. Both these detectors provide relatively poor performance as compared to the optimum, while the logarithmic and binary detectors provide performance that approaches the optimum under certain conditions. In addition, the performance in Rayleigh and log-normal clutter is compared for the various detectors analyzed and for the optimum, allowing the radar designer to estimate the variation in performance for different receiver selections if the two types of clutter exist in the same field.

Marcum-Swerling analysis

The Marcum-Swerling analysis is an application of statistical decision theory to detection problems. This theory provides an optimum procedure for deciding between the alternate hypotheses of clutter alone or signal plus clutter.

Central to this method is the formation of the logarithmic LR test that specifies the optimum receiver structure or detector law to be applied to the input signal. In general, the receiver structure consists of a zero memory non-linearity followed by a linear integrator. For Rayleigh distributed

Figs. 1 and 2 show detection probability for log and linear



D C Schleher is with AIL in Deer Park, New York.

clutter the resulting detector law consists of the $\log 1_0(v)$ detector that is approximated by a linear detector with quadratic curvature for small signal-to-clutter ratios.

Under the Neyman-Pearson criteria the decision threshold value is determined by fixing the probability of false alarm at a specified value. The Neyman-Pearson criteria provides an optimum test for the radar case.

When the Marcum-Swerling analysis is applied to the log-normal clutter situation, an immediate problem is encountered—the likelihood ratio cannot be found in closed form. This is a consequence of the lack of an analytic expression for the probability density under the signal plus clutter hypothesis. The net result is the likelihood ratio can only be obtained numerically and a general form for the optimum receiver in log-normal clutter cannot be obtained.

In this article an alternate procedure is followed. A Chernoff bounding process is determined following a method described by Van Trees. This allows the optimum receiver performance to be closely approximated by an Edgeworth series expansion. Then the performances of practical receiver structures are evaluated and compared against this performance bound, to determine quasioptimum receivers.

Receiver performance is determined using a characteristic function approach in which the transforms are evaluated using the Fast Fourier Transform (FFT). The availability of the FFT makes this approach viable with a practical amount of computer time.

Detector performance

The linear receiver is known to approximate the optimum receiver in Rayleigh distributed clutter. Since many radars are designed with linear receivers, on the basis of a Rayleigh clutter assumption, it is important to determine how these receivers perform in log-normal clutter.

Log-normal clutter is characterized by its mean-to-median ratio, ρ . The range of this parameter can be determined by examining available log-normal clutter data. Log-normal sea-clutter data has been measured by many workers. The values of ρ range from about 0,6 dB measured by NRL for a relatively high grazing angle of 4,7 degrees and low sea state to 5,75 dB measured by APL for a high sea state and low grazing angle of 0,5 degree.

Ground clutter data measured by the Royal Radar Establishment shows a ρ of about 2,6 dB for low grazing angles. Radar angles have a reported ρ that varies from approximately 3 dB to 4 dB.

Figure 1 shows a comparison of the performance of the linear receiver in Rayleigh and log-normal clutter ($\rho = 1, 3, 5$ dB) for n equal to 30 inde-

pendent samples and a false alarm probability of 10^{-5} . A comparison of the signal-to-median clutter differential for equal probability of detection ($P_d = 0, 9$, $P_{fa} = 10^{-5}$) in Rayleigh and log-normal clutter is given in Table 1. Examination of this table shows severe performance degradations in log-normal clutter.

n	ρ -Mean-to-Median Ratio		
	1 dB	3 dB	5 dB
1	9,6	28,0	39,0
3	7,8	25,0	36,4
10	5,4	21,2	33,2
30	3,0	17,6	30,0

Table 1. Linear Receiver Performance Degradation in Log-Normal Clutter (Differential Signal-to-Median Clutter Ratio in dB).

Logarithmic receiver

A logarithmic detector has an output voltage whose amplitude is proportional to the logarithm of the input envelope. This type of detector has found extensive use in Rayleigh distributed clutter since it has the property that it provides a constant false alarm rate (CFAR).

The detection performance of the logarithmic receiver (logarithmic detector with a linear integrator) in a Rayleigh background has been analyzed by Green. He found that the performance loss with respect to an optimum receiver was 0,5 dB for 10 pulses and 1 dB for 100 pulses. He conjectured that the loss was proportional to the logarithm of the number of pulses integrated.

The performance of the logarithmic receiver in log-normal clutter is found by appropriately transforming the envelope distributions under the alternate hypotheses of clutter (H_0) and clutter plus signal (H_1) and applying the Marcum-Swerling analysis. A logarithmic transformation is applied to the normalized log-normal ($R_m = 1$) and Log-Rician envelope detected distributions

$$V = 1nR \quad (1)$$

The resulting distribution under the clutter hypothesis (H_0) is normally distributed

$$f_1(V_0|H_0) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-V_0^2/2\sigma^2\right) \quad (2)$$

The distribution under the signal plus clutter hypothesis (H_1) is given by:

$$f_1(V_1/H_1) = \int_0^{2\pi} \frac{e^{sV}}{(2\pi)^{3/2}\sigma}$$

$$\frac{-1n^2 \left(e^{\frac{2V}{\sigma}} - 2Ae^{\frac{V}{\sigma}\cos\theta} + A^2 \right)^{1/2}}{2\sigma^2} \quad (3)$$

where the variable V_s extends from $-\infty$ to $+\infty$.

Figure 2 shows a comparison of the performance of the logarithmic receiver in Rayleigh and log-normal clutter ($\rho = 1, 3, 5$ dB) for n equal to 30 independent samples and a P_{fa} of 10^{-5} . A comparison of the signal-to-median clutter differential for equal probabilities of detection ($P_d = 0,9$; $P_{fa} = 10^{-5}$) in Rayleigh and log-normal clutter is given in Table 2. The performance for a single pulse is almost identical to the linear receiver. However, as the number of pulses increases to 30 the performance increases dramatically.

The overall performance of the logarithmic receiver across a range of log-normal to Rayleigh clutter is good for values of ρ less than 1 dB and n greater than 10. As the value of ρ increases, the performance degradation is significant. However, for n equals 30, the performance spread is modest even for large ρ .

n	ρ -Mean-to-Median Ratio		
	1 dB	3 dB	5 dB
1	10,0	27,8	40,0
3	4,2	14,0	20,8
10	1,0	6,1	9,6
30	-0,4	2,3	4,2

Table 2. Logarithmic Receiver Performance Degradation in Log-Normal Clutter (Differential Signal-to-Median Clutter Ratio in dB).

Integrator performance

The binary integrator is a digital detection process that utilizes a double threshold. It is shown diagrammatically in Figure 3. The envelope detected signal is compared to the first threshold. The number of threshold crossings in n repetitions of signal is counted. When more than m crossings take place in the n trials, a target is assumed to be present.

Schwartz determined that the second threshold for a Rayleigh distributed envelope detected background should be set as approximately $1,5n$ for optimum detection. This result is true for a broad range of false alarm probabilities (10^{-5} to 10^{-10}) and probability of detections (0,5 to 0,9). The performance of this suboptimum detector in Rayleigh clutter is within 1,5 dB of the optimum performance.

The optimum value of m for different values of n has been found by forming detection curves for each possible

value of m and determining the best value. The optimum value of m found for n , equals 3, 10, and 30 is given in Table 3 for the log-normal (m_{opt}) and the Rayleigh distributions ($m_r = 1,5 \sqrt{n}$).

n	m_{opt}	m_r
3	2	2
10	7	4
30	24	8

Table 3. Optimum Value of Second Threshold-Log-Normal Clutter.

Performance curves of the binary integrator in log-normal clutter with ρ equal to 1 dB are given in Ref. 9, n equal to 3, 10 and 30. The performance compares favourably with that of the linear and logarithmic receivers.

Median detector

The median detector can be examined from two different viewpoints. The more fundamental approach operates by finding the median of the input distribution and comparing this against a threshold. This approach is difficult to implement since it requires storing the amplitudes of n individual samples, ranking the samples, and then finding the median. Alternately, the median detector can be implemented by employing the binary integrator with the second threshold set at $m = (n-1)/2$. This produces the same effect since if the majority of samples exceeds the first threshold, then the median must exceed the second threshold and a target is declared.

The performance of the median detector for n equal to 3, 10, and 30 in log-normal clutter ($\rho = 1$ dB) for a false alarm probability of 10^{-6} is given in Ref. 9. The performance of the median detector is superior to the linear receiver but inferior to the binary integrator and logarithmic receiver.

The robustness of the median detector can be estimated by considering its performance over a range of log-normal to Rayleigh clutter. Using Rayleigh data from Schwartz and log-normal ($\rho = 1$ dB) clutter data for an integration of 10 pulses with a P_{fa} of 10^{-5} and P_d values of 0,5 and 0,9 shows that the performance is reasonably robust when the small number of samples (10) is considered (Table 4).

Optimum performance

The Chernoff bound provides upper bound in the form of an exponential relationship. Van Trees tightened the upper bound by finding a multiplicative factor for the exponential relation using a central limit theory argument. The extension in this article essentially consists of a development of higher

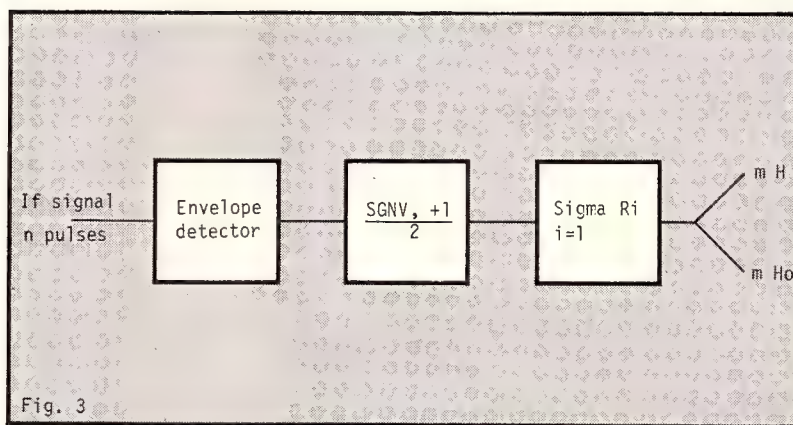
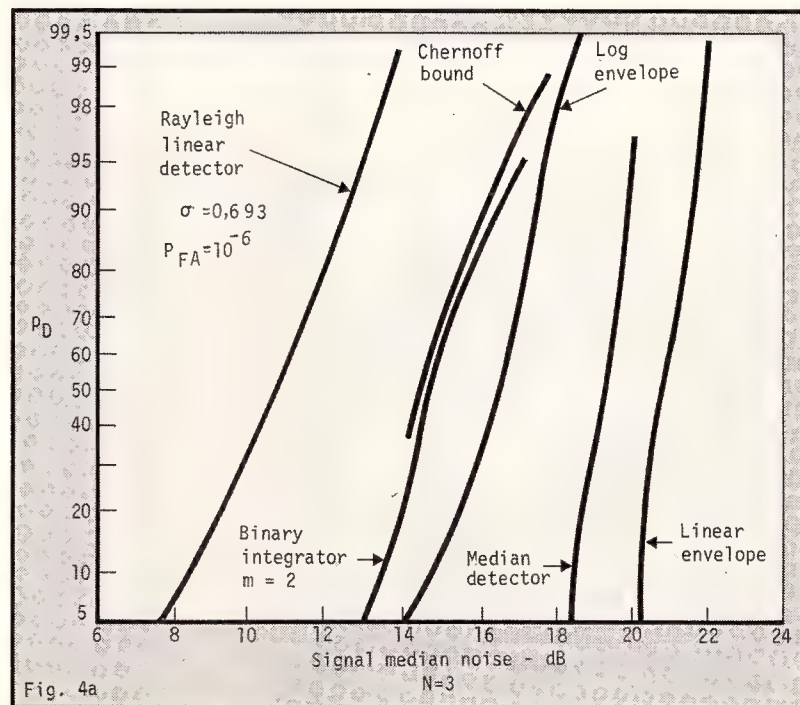


Fig. 3 shows a typical binary integrator.

Fig. 4a shows performance of new receivers for $N=3$.



order terms in a series expansion for the performance, rather than a determination of a multiplicative factor in an upper bound.

Median Detector			Optimum	
P_d	S/NR	$S/N LN$	S/NR	$S/N LN$
0,9	8,2	10,0	7,4	8,4
0,5	6,5	8,6	5,9	6,8

Table 4. Signal-to-Median Clutter in dB for Median Detector ($P_{fa} = 10^{-5}$).

The moment generating function for the clutter hypothesis is given by:

$$\theta_{|H_0}(s) = E(e^{sI} / H_0)$$

$$= \int_{-\infty}^{\infty} e^{sI} f_1(I/H_0) dI \quad (4)$$

The semi-invariant of the clutter hypothesis is defined:

$$\begin{aligned} \mu(s) &= 1n\theta_{|H_0}(s) \\ &= 1n \int_{-\infty}^{\infty} e^{sI} f_1(I/H_0) dI \end{aligned} \quad (5)$$

However, the semi-invariant, $\mu(s)$, cannot be found since it is expressed in terms of the unknown density $f(I/H_0)$. But $I(v)$ is just a function of v and hence equation 5 can be written as:

$$\begin{aligned} \mu(s) &= \\ 1n \int_{-\infty}^{\infty} [f_v(v|H_1)]^s [f_v(v|H_0)]^{1-s} dv \end{aligned} \quad (6)$$

Equation 6 allows the semi-invariant,

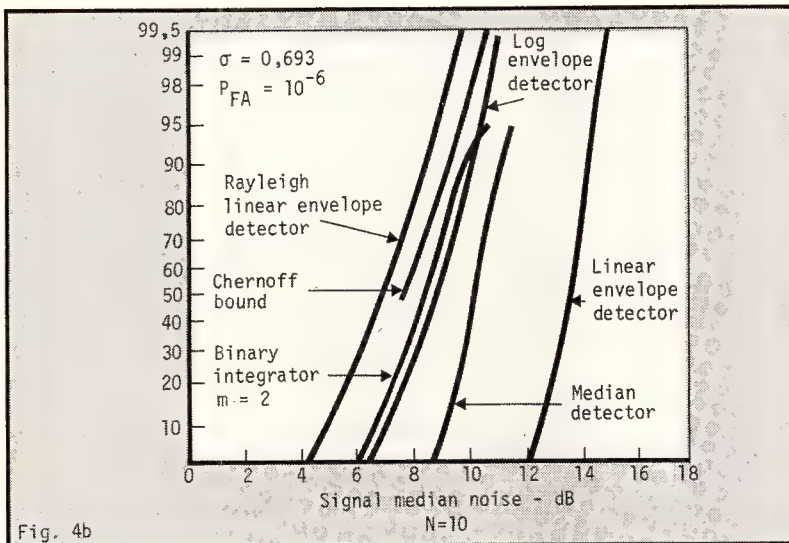


Fig. 4b

Fig. 4b is receiver performance for $N=10$.

Fig. 4c Finally comparison is made for $N=3$.

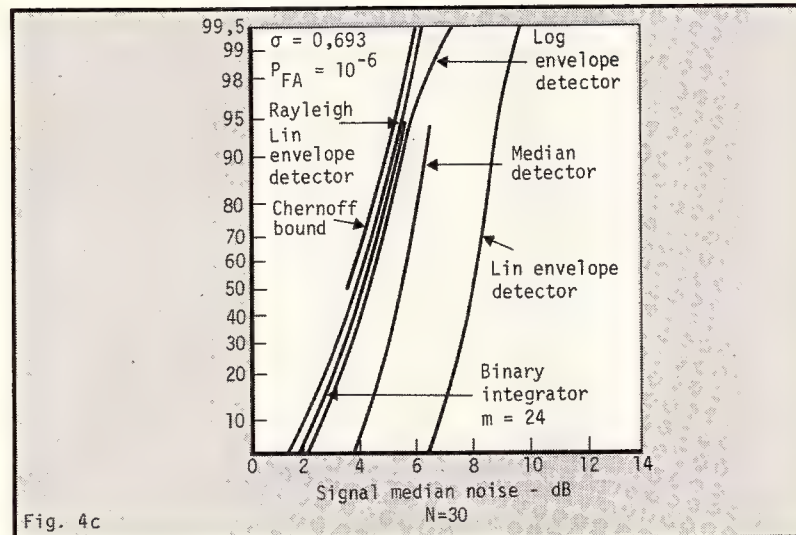


Fig. 4c

$\mu(s)$, to be calculated as a function of s .

The procedure of finding P_{fa} and P_d is as follows. Equation 6 is evaluated by Gaussian quadrature for a particular signal value over a range of s from 0 to 1, derivatives of $\mu(s)$ are evaluated by numerical differentiation techniques (spline functions), a receiver operating curve is generated plotting P_d versus P_{fa} for a particular signal, and Marcum-Swerling curves are generated using the receiver operating curves.

Reference 9 shows that P_{fa} is given by:

$$P_{fa} = \frac{1}{2} \operatorname{erfc}[\alpha(s)] \cdot e^{\alpha^2(s) + B(s)} - \frac{\mu(s)}{6 [\mu(s)]^{3/2}} e^{B(s)}$$

$$\left\{ \frac{1}{2} \operatorname{erfc} \alpha(s) \cdot [s \sqrt{\mu(s)}]^3 e^{\alpha^2(s)} + \frac{1}{\sqrt{2\pi}} [1 - s^2 \mu(s)] \right\} \quad (7)$$

where

$$\alpha(s) = s \left[\frac{\mu(s)}{2} \right]^{1/2} \quad (8)$$

and

$$B(s) = \mu(s) - s \mu(s) \quad (9)$$

From equation 7 it is apparent that P_{fa} can be expressed in terms of the semi-invariant of the likelihood ratio, $\mu(s)$ and its derivatives.

An expression for P_m ($P_m = 1 - P_d$)

can be found by substituting $1-s$ for s in equations 7, 8 and 9.

The previously developed expressions for P_{fa} and P_m are easily extended to consider n independent samples. Modifying equation 6 for n samples and noting that all integrals are identical results in

$$\begin{aligned} \mu_n(s) &= 1n \left\{ \int_{-\infty}^{\infty} f_v(v|H_1) s f_v(v|H_0)^{1-s} dv \right\}^n \\ &= n \mu(s) \end{aligned} \quad (10)$$

Hence $\mu(s)$ is simply scaled by the number of independent samples. The P_{fa} and P_m for the n independent sample case is found by utilizing the scaled value of the semi-invariant, $n\mu(s)$, in equation 7.

Evaluation of equation 7 for P_{fa} and P_m requires determination of the first, second, and third derivatives of $\mu(s)$. In general this is difficult numerically. A method to provide excellent results is to fit the data points that determine $\mu(s)$ by a cubic spline function. The derivatives are obtained by differentiating the spline function. The spline function has the characteristic that it produces the smoothest curve through the data points while maintaining continuous derivatives at these points.

Receiver operating curves are given in Ref. 9. Translation of the receiver operating curves into Marcum-Swerling type curves for comparison with practical receiver configurations previously evaluated is easily accomplished. Curves are presented in the next section that provide this comparison and also allow comparison between optimum performance in Rayleigh and log-normal clutter backgrounds.

Receiver comparison

Curves showing the performance ($P_{fa} = 10^{-6}$) of the linear receiver, logarithmic receiver, binary integrator, and median detector in log-normal clutter ($\rho = 1$ dB) are given in Figures 4A, 4B, and 4C for n equal 3, 10, and 30 independent samples. Also shown on these curves is the optimum performance in log-normal clutter ($\rho = 1$ dB) and Rayleigh clutter.

The performance of the binary integrator is the best of the receivers considered—approaching the optimum bound, while the performance of the linear receiver is the poorest. This is significant since many radars are designed using linear receivers, optimized for Rayleigh clutter, but must operate in log-normal clutter. When this occurs the performance penalty is severe. A more rational philosophy is to design the receiver to operate over a range of Rayleigh to log-normal clutter by utilizing one of the nonlinear re-

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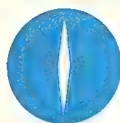
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ceivers identified in this paper.

The performance of the logarithmic receiver is almost as good as the binary integrator and has the added advantage that it is easily implemented. In addition, it provides the high receiver dynamic range necessary to handle the wide range of clutter amplitudes usually encountered. Furthermore, it provides a CFAR capability in Rayleigh distributed clutter.

The performance of the median detector is relatively poor compared with the other nonlinear receivers analyzed and the optimum bound; but it is definitely superior to the linear receiver. This receiver is most valuable in the nonparametric situation where little is known about the clutter distribution.

Performance comparison

The curves given in Figure 4 allow an interesting comparison to be made between the performance in log-normal ($\rho = 1$ dB) and Rayleigh clutter. Table 5 gives the signal-to-median clutter ratio required to provide P_d of 0,9 and a P_{fa} of 10^{-6} in both log-

<i>n</i> -Independent Samples				
	1	3	10	30
Rayleigh	16,4	12,4	8,4	5,2
Log-Normal	27,4	15,6	9,2	4,8

Table 5. Signal-to-Median Clutter Ratio in dB for $P_d = 0,9$; $P_{fa} = 10^{-6}$.

normal ($\rho = 1$ dB) and Rayleigh clutter for n equals 1, 3, 10, and 30 independent samples. For one sample the performance is 11 dB poorer in log-normal clutter, while for 30 samples the

<i>n</i> -Independent Samples			
	3	10	30
Rayleigh	4,0	8,0	11,2
Log-Normal	11,8	18,2	22,6

Table 6. Integration Gain in dB for Rayleigh and Log-Normal Clutter.

performance is about equal. This illustrates that non-coherent integration is more effective in log-normal clutter than in Rayleigh clutter. The integration gain is given in Table 6. It is seen that for log-normal clutter the situation exists whereby the integration gain is greater for noncoherent integration than it would be for coherent integration of a Gaussian distribution (10 log).

Log-normal distribution

The log-normal probability density function is given by:



Typical applications for radar in military systems.*

$$f(R) = \frac{1}{\sqrt{2\pi}\sigma^2 R} \exp\left\{-\frac{1n^2(R/R_m)}{2\sigma^2}\right\}; R > 0 \quad (11)$$

where R_m is the median value of R and σ is the standard deviation of the generating normal distribution.

A parameter commonly used to characterize the log-normal distribution is the mean-to-median ratio (ρ)

$$\rho = \frac{E(R)}{R_m} = \exp\left\{\frac{\sigma^2}{2}\right\} \quad (12)$$

Log-Rician density function

In this article, the amplitude probability density function associated with an envelope detected signal in log-normal clutter is called the Log-Rician density function. The procedure used by Rice to determine the Rician distribution is followed to determine the Log-Rician distribution.

From Ref. 9 the Log-Rician density function is given by:

$$f(R_s) = \int_0^{2\pi} \frac{R_s}{(2\pi)^{3/2} \sigma}$$

$$\exp\left\{\frac{-1n^2(R_s^2 - 2AR_s \cos\theta + A^2)^{1/2}}{2\sigma^2}\right\} d\theta$$

$$R_s^2 - 2AR_s \cos\theta + A^2$$

It is noted that this density reduces to the log-normal density for $A = 0$.

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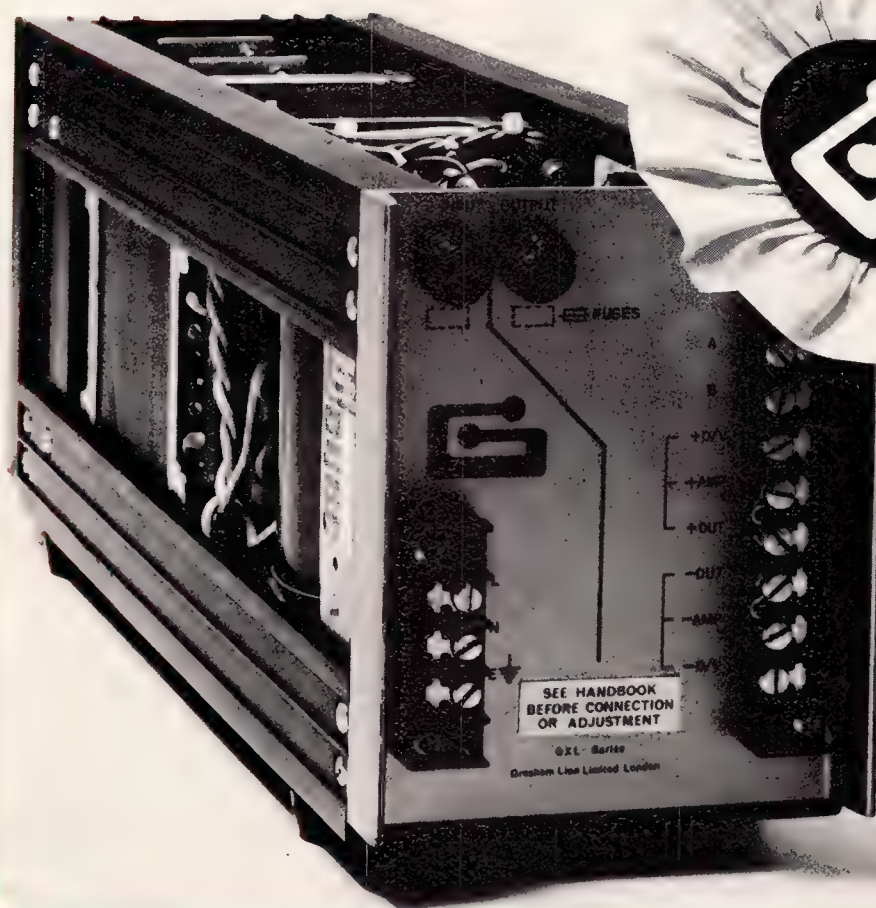
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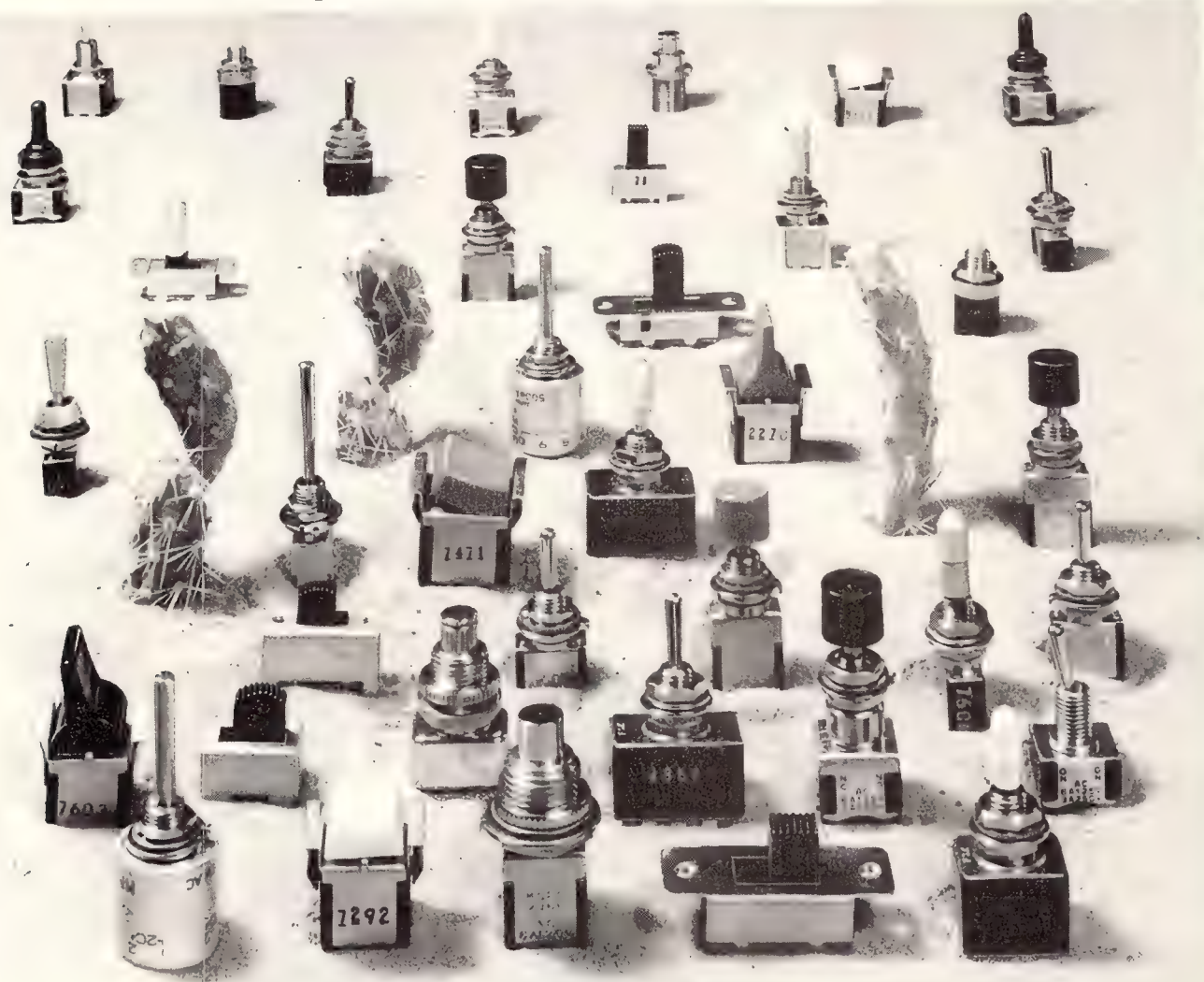
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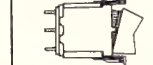
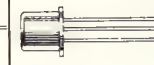
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European solid state conference report

This year Toulouse University hosted the second international solid-state circuits conference. *Elaine Williams* describes some of the papers presented on current and future technologies ranging from memories to opto-electronics.

The second ESSCIRC conference provided not only an opportunity to catch up on the research being carried out in semiconductor technology, but also the chance to fly the European Airbus and become trapped in the lift at the space-age Charles DeGaulle airport. Having survived a few minor disasters the conference proved to be worth the effort with many interesting papers being presented on current and future technologies.

Seven invited papers were given which covered the main themes of the conference, such as, advanced mos-fet technologies; the future of bipolar techniques; silicon-on-sapphire; logic arrays, lsi in watches and high speed GaAs circuits. The increasing conflict between bipolar and mos lsi technologies were highlighted in a paper from Victor Blatt of the Allan Clark Research Centre, entitled 'The present and future of bipolar technology'. He commented on the advantages of both bipolar and mos technologies and the fact that research in these technologies was being aimed at increasing the speed of mos and increasing chip density for bipolar. Blatt also stated that very simple bipolar processes exist that are capable of exceedingly good yields and that triple diffusion could economically produce chips larger than 50 mm². Collector diffused isolation was another simple process, capable of reasonable performance and good yields.

Low-power Schottky ttl

Blatt saw the future of bipolar logic families being centred around ecl and low power Schottky ttl. Although the former has had a disappointing growth, it is expected to become the dominant technology for large computers in three or four years time; whilst the latter promises to become the most popular logic family by offering a combination of 5 ns gate

delays with 2 mW/gate lower dissipation, coupled with falling prices due to increasing volumes.

Finally Blatt stated that with a density of 1000 gates/mm² for Schottky l²l, it was not difficult to imagine five and 10 000 gate bipolar circuits; if the main yield hazard of fast bipolar processes, such as collector-emitter shorts and leakages were solved, he believed that bipolar technology could not only defeat mos in performance and flexibility, but also compete in cost.

Joseph Borel speaking on advanced mos-fet technologies claimed that mos technologies have been improving their speed to such a level that presently they are able to attain Schottky ttl speeds with a reduced power consumption in the order of ten to fifty times. He believed that they would take an increasing part of the Schottky ttl market. He went on to describe two advanced technologies, dmost and vmost, which are double diffused mos-fet devices with an extra diffusion in the source to form the channel and a mos-fet built with a V-notch obtained by an anisotropic etch in bulk silicon, which could provide the necessary speed. He believed that the present range of materials and devices limited the freedom for innovation. Gallium Arsenide could prove to be an interesting material although GaAs technology is not so well understood or controllable as is

that of silicon; but he thought that only a limited number of improvements could be made using existing silicon devices and that the characteristics of existing devices would have to change dramatically.

Borel considered it was likely that a cmos on sos technology or cmos on bulk, could provide more complex lsi for the same power consumption and higher clock rates with reasonable power consumption. He quoted a maximum frequency improvement for cmos on sos, in the order of a factor of five to eight, with lower benefits for cmos on bulk. It is believed, he continued, that very large scale integration would be the desire of many companies and this would require a complementary shrunk mos to achieve the chip complexity, yield and reduced power.

GaAs semiconductors

The exploitation of GaAs as a semiconductor material was discussed by Robert Veilex in his invited paper, 'High speed GaAs circuits'. At present the substrate material to fabricate mes-fet's from GaAs is poor, although great improvements have been made in the technology because of the interest of the material in optoelectronics and microwave components. This device gives a better performance than silicon and some research has been undertaken in the USA and Japan into exploiting the Gunn effect, but the device is complex

and has limitations in application, as well as being a long term development project.

Mes-fet devices

The present mes-fet devices consist of a thin active layer (0.25 µm), deposited on a semi-insulating substrate. The current flowing between two ohmic contacts is controlled by a narrow gate (1 or 2 µm). The drain-source separation is 3 to 4 µm and the width of the transistor is between 10 and 200 µm with a cut off frequency of about 40 GHz.

Mr Veilex said, 'The major difficulty was the realisation of the active layer'. This is usually made by means of a liquid or vapour phase epitaxy, but molecular beam epitaxy and ion-implantation have been tried.

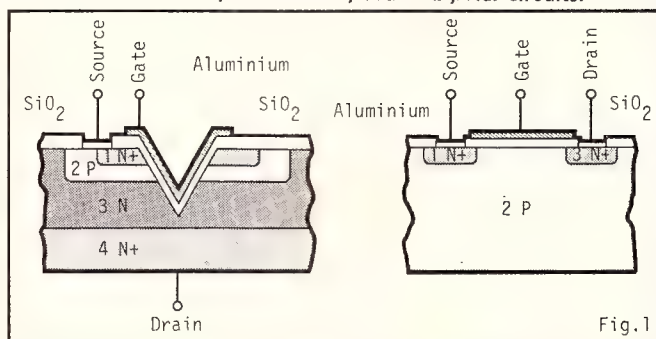
The technique used by Roger Veilex and his colleagues at the Laboratoire d'Electronique et de Physique Appliquée, employs four masks and uses a self registration technique for mask alignment with an electron beam pattern generator to overcome the problem of mask alignment. Hewlett-Packard are also involved in the fabrication of these devices but the company uses five masks for its process.

Apart from mes-fet devices many other types could be produced in GaAs materials, such as sig-fet's and a metal j-fet. Some researchers are working on the production of normally-off transistors, these devices it is anticipated will pave the way for very low consumption circuits with only one power source, but this is paid for by a degradation of speed.

Mr Veilex concluded his paper by stating that GaAs offered some specific properties such as Gunn effect, luminescence and acoustoelectric effects. He could envisage circuits with unusual characteristics, such as optical coupling between chips or parts of chips for interconnections.

Returning to bipolar technology Nagata, Kaneko and

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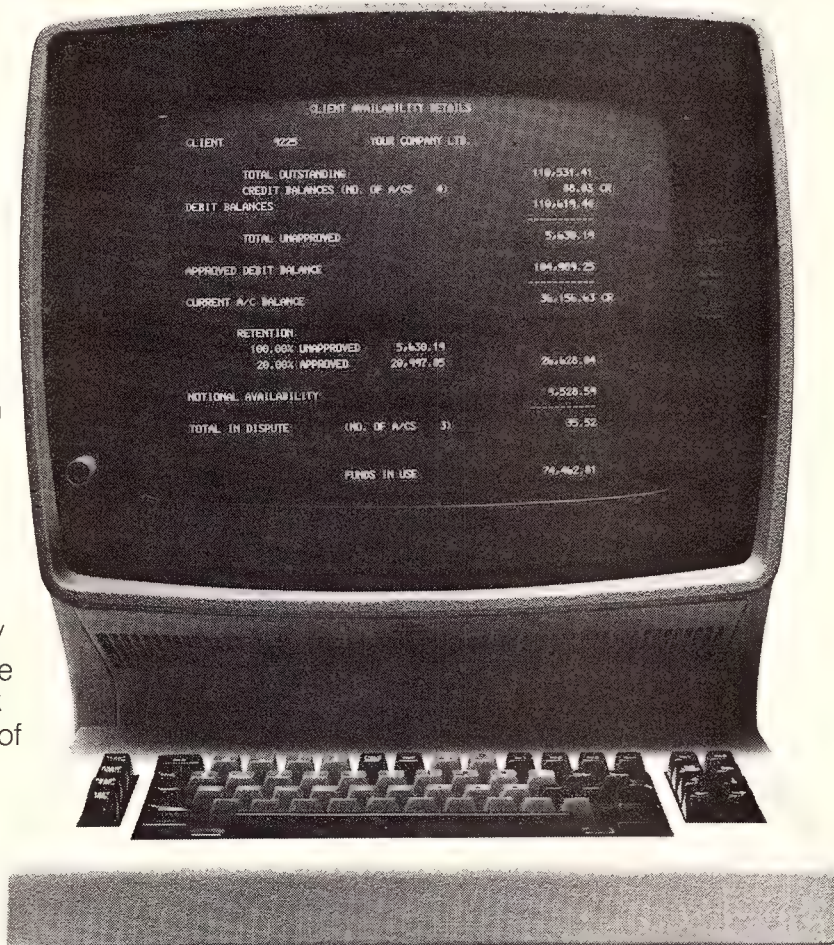
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Okabe from Hitachi, proposed a stacked I²L circuit to cut down the effective power dissipation to one third that of conventional I²L. In its conventional form the injector current is provided through a resistor or constant current source. Almost 86% of the power is dissipated in this resistor for a supply voltage of 5 V. In the stacked circuit *m* blocks of I²L are produced by stacking layers of I²L circuits. In this circuit configuration the dc bias is supplied to the first layer and then travels up through the other layers almost simultaneously. Up and down driving circuits are required for transferring a signal from a lower to an upper surface. The layers also have to be isolated, but this is achieved by using conventional techniques and the packaging density loss is usually between 10 and 20%. Mr Nagata, who was presenting the paper, stated 'The power dissipation is 1/*m* times that of conventional circuits for the same logic functions'. The total power is of course decreased in proportion to the number of layers in the

stack. The stacked I²L circuit proposed, automatically distributes the injector current to each layer without use of an additional circuit driver. This is achieved since the voltage across each layer is automatically determined by a diode string, formed by the base emitter junction of the injector.

Meanwhile, Nuzillat, Pham-Ngu and Helioui were rethinking the concept of bistable complementary bipolar circuits. Using present bipolar ideas the researchers from Thomson-CSF defined a new logic family designated twin-transistor injection logic (T²IL), which is I²L compatible and can be made using a standard process.

Substrate fed logic

There was great interest in injection logic and members of the Allan Clark Research Centre, Walsh and Sumerling, gave their paper on Schottky I²L (or substrate fed logic) which is an advanced form of I²L. It is claimed that delays of about 10 ns with a power dissipation of 50 µW are attainable with high

packing densities. From initial yield evaluation gates, structures of 1000 could be obtained.

The basic gate comprises a switching npn transistor with Schottky diode inputs in addition to the conventional multi-collector output and a substrate pnp injecting transistor. Improvements have been made to the p-type implant used, to provide a high doping concentration under the Schottky contact. Also boron is implanted in all regions except collectors. Walsh and Sumerling claim that this structure provides a low concentration gradient under the Schottky for higher breakdown voltages; higher doping under the Schottky to prevent parasitic electron collection; a surface channel stopper; as well as a reduction in base resistance; a lower power delay product; lower current and high gain and transconductance.

Other papers given at the conference were concerned with circuit applications, such as an I²L two tone dialling circuit for telephony, described by Kaire and Guetin and high density

monolithic bipolar and mos arrays for private branch telephone exchanges, presented by a group from AEG-Telefunken.

Memories, too, were still a topic for discussion, Jean Michel Ayache discussed the design of a very large scale integrated memory. The memory is composed of partly faulty lsi chips and reconfiguration circuitry, which masks any faulty bits to reduce the number of rejected circuits for vlsi. Siemens researchers, Mitterer and Rehn, explained the design of a 16k mos-ram in double polysilicon technology. The circuit uses refined techniques, in that the double polysilicon approach leads to a cell density of approximately 2000 bit/mm², without extreme shrinking of structures.

The circuit uses a transfer gate instead of switching transistors. This gate is formed by the first polysilicon layer and the storage capacitor is formed in the second layer. A diffusion area in the cell is omitted and this saves space as well as reducing leakage currents.

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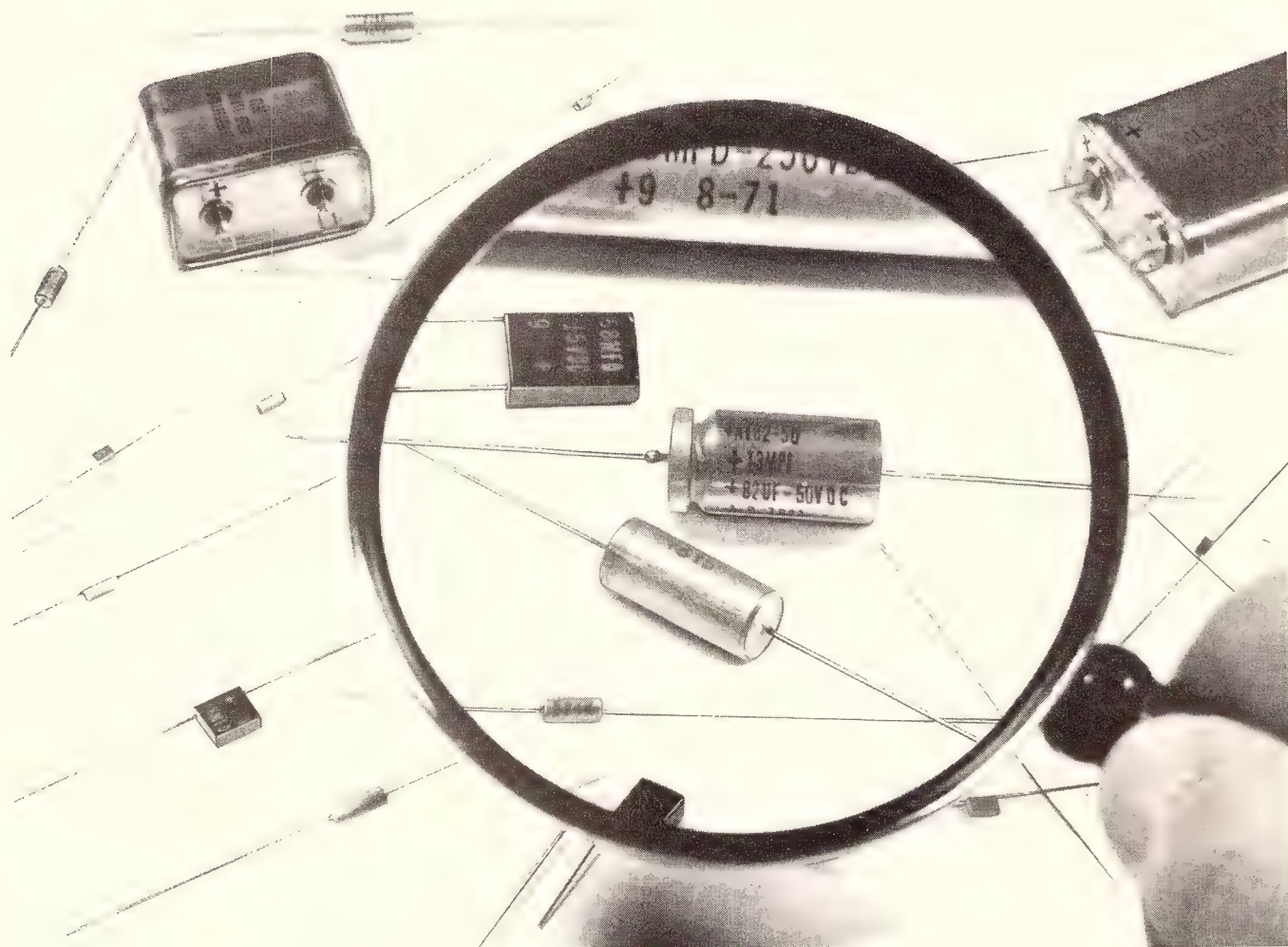
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In constant use, mainly in London traffic, this editorial car has clocked up 18 000 miles since the conversion. In this time, the ignition has not had to be touched and the car is showing a slight improvement in fuel consumption. Unfortunately precise records were not kept prior to the conversion, but the improvement in fuel consumption appears to be higher than the 4 to 5% obtained by the Motor Industries Research Association when comparing it with a tuned conventional unit.

For the motorist who does more than 12 000 miles a year, fuel savings alone would appear to justify the costs of conversion. In our trials conversion costs were amortised in less than a year.

Also a case can be made from a practical point of view. Once the electronic ignition system has been correctly installed, there is no reason why it should need to be touched during the lifetime of the vehicle: theoretically it should stay in tune indefinitely. This seems to be very relevant for most reports on this subject have compared electronic solutions with correctly adjusted traditional systems.

Wear is inevitable with conventional "Kettering" electro-mechanical ignition systems. Actually it starts at the time of installation and can be quite serious within 10 to 15 000 miles. Pitting on the contact points and wear on the whole assembly can throw the timing way off—with the plugs failing to ignite all the fuel in each cylinder. As a consequence, both fuel and pollution levels increase. It is hardly surprising when one examines the traditional (crude by electronic standards) method of pulse switching. A six-cylinder engine running at 4000 rpm (typical cruising speed revs) requires a high voltage pulse every five milliseconds.

For the field trials, Mobelec of Oxted, Surrey, fitted one of their type E20 inductive pick-up, capacitor discharge systems. It took about an hour to install: the biggest problem was finding a place to mount the electronics package in the engine compartment.

Immediately we noticed an improvement in tickover and the acceleration appeared to be better, but this may have been due to the poor state of tuning prior to the conversion—or to the feeling that it ought to be better.

Figure 1 shows the inductive pick-up fitted to the top of the distributor. It replaces the conventional set of points and provides the trigger pulse needed to discharge a high voltage capacitor across the primary of the vehicle's ignition coil. The capacitor, an integral part of the electronics package, is charged by a solid state converter which raises the vehicle's 12 volt supply to around 400 volts. This results in a much higher potential on the coil secondary—typically 40 kV.

Figure 2 shows typical high voltage

Electronic ignition looks right for motor vehicles

Following up a report on various types of electronic ignition systems for motor vehicles — published in December 1974 — a contactless-type of capacitor discharge system has been operating successfully in a six-cylinder Triumph 2000 for more than a year. Our tests have been encouraging.

outputs for Mobelec's Model 20 and 40 capacitor discharge systems: the latter is for high revving engines and eight-cylinder models. Note the flatness of both and how cut off extends beyond that of a conventional unit.

Besides a better high speed characteristic, the electronic systems perform well at low speed and draw minimal current in the quiescent (idling) state. Typically current demand extends from 600 mA to 3 A at maximum output for the E20 unit. This compares very favourably with the traditional electro-mechanical system which draws more current at tickover than at cruising revs. This feature makes starting much easier, particularly in cold weather. Engineers at Mobelec maintain that you get first time starting with capacitor

discharge ignition down to -40°C .

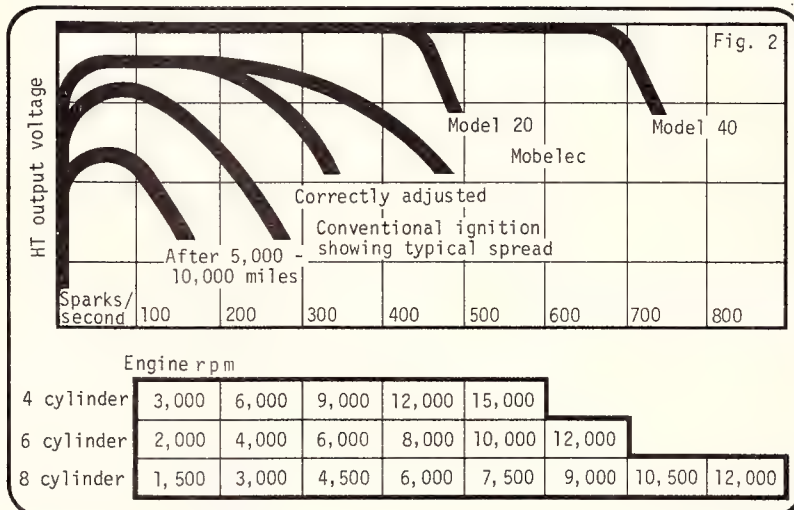
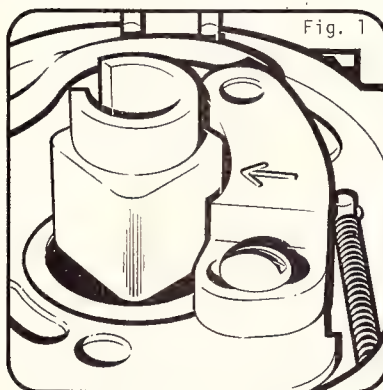
As already mentioned, the ignition system has not been touched. Although colder running plugs could have been fitted, the standard plugs were retained, with the gaps stretched to 30 thou. but there were no signs of wear or fouling. Literature suggests that plugs should be changed between 15 and 30 000 miles, depending upon operation.

Electronic ignition is being fitted by several high volume manufacturers in the United States. In part, this must be due to the stricter pollution controls in the U.S. and California in particular. Laboratory trials have shown that electronic units help reduce exhaust pollution levels, by ensuring more constant cylinder temperatures and efficient fuel burning.

No doubt the British car makers will wake up to the advantages of electronic ignition for mass-produced cars. Certainly it would cost around £5 more than traditional solutions: add on units cost about £25.

One may expect a 4 to 8% fuel reduction, a saving of 10 to 15 sets of contact points (not cheap these days) and 5 to 10 sets of spark plugs. One cannot put a price on the fringe benefits: good cold starting, freedom from plug fouling in traffic and reduced vibration.

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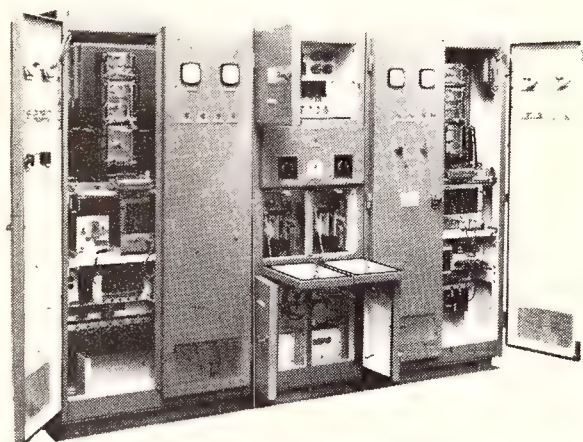
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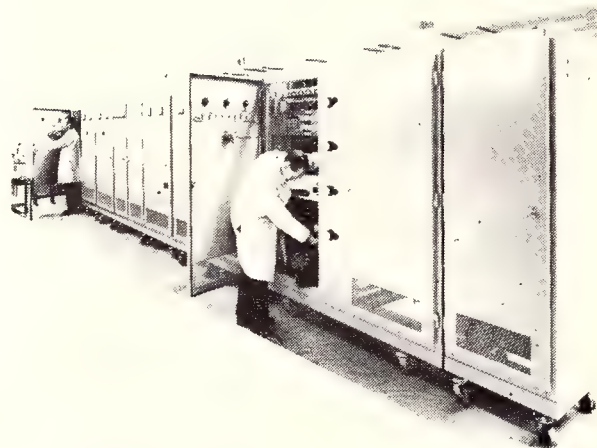
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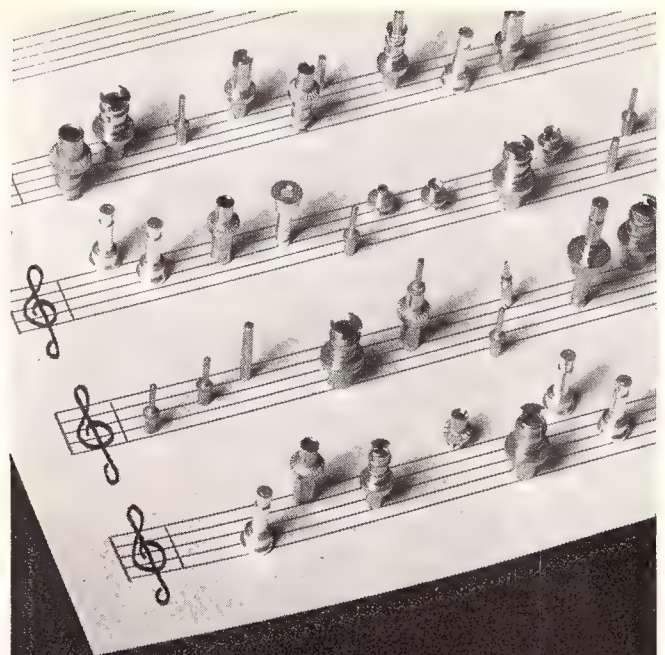
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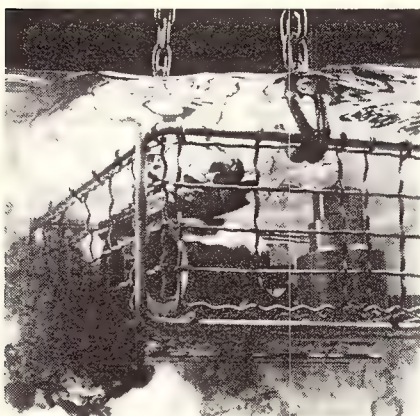
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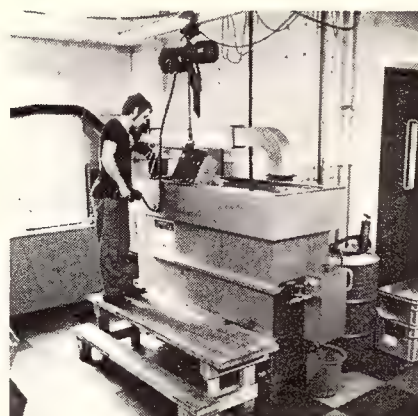
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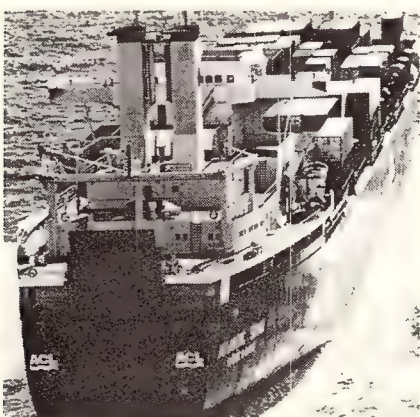
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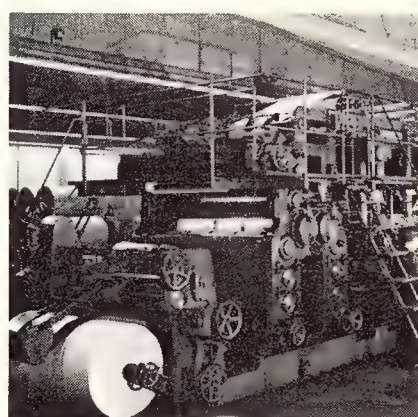
Vapour degreasing



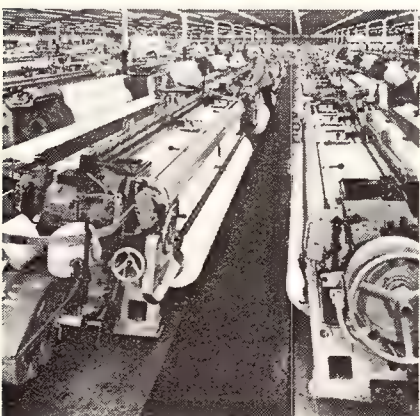
Marine Industry



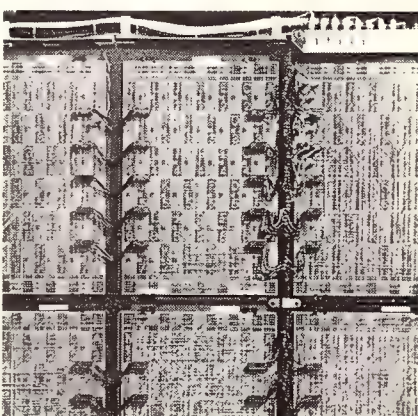
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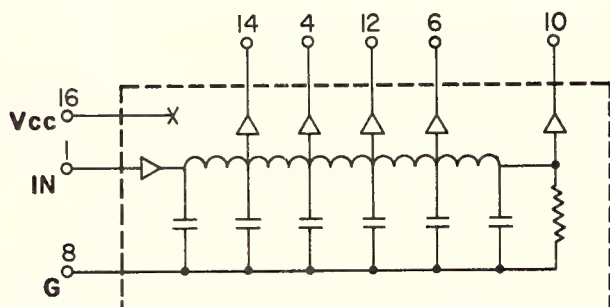


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Example



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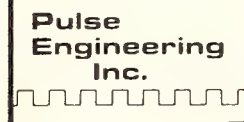
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All inquiries, on any aspect of this advertisement, should be addressed to: Mike Jones, Sales Manager, Sprague Electric (UK) Limited, 159 High Street, Yiewsley West Drayton, Middx. Telephone W. Drayton 44627, telex 261524.
49 on enquiry card



RIFA

Glass encapsulated 1A Diodes PAB 219

For immediate delivery

The original GE (USA) design,
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Glass diodes in general are better than plastic diodes, with better performance, longer life, fewer breakdowns and hermetic sealing suitable for tough environments and for use in potted circuits.

RIFA PAB 219 glass diodes are better than ordinary glass diodes, for a number of reasons:—

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4 Low Power Voltage drop is lower than in conventional glass diodes; 0.9V for 1A compared with the usual 0.96-0.99V. In a big circuit this adds up.

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PAB 219 diodes are ideal for Telecommunications, data transmission and computer peripheral circuits (long life and low

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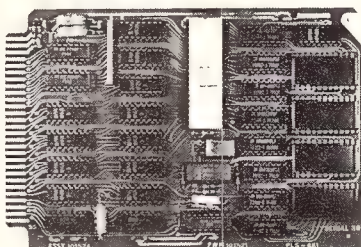
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THE PLS-881



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This is a complete 8080 microprocessor system mounted on a single 6½" x 4½" containing 8080, sockets for 4K of PROM, 1K of RAM, 16 I/P lines, 24 O/P lines and crystal clock. Systems using 4004, 4040 and M6800 also available.

Technitron

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THE SERIES 90 PROM PROGRAMMER

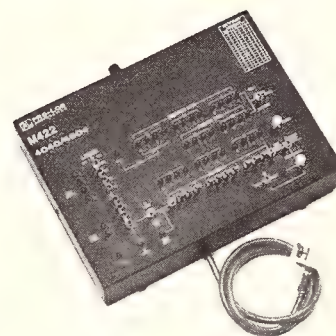
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- ★ Run/stop and single cycle operation
- ★ Counter for 100p control Analysers available for 4004, 4040, 8080 & M6800

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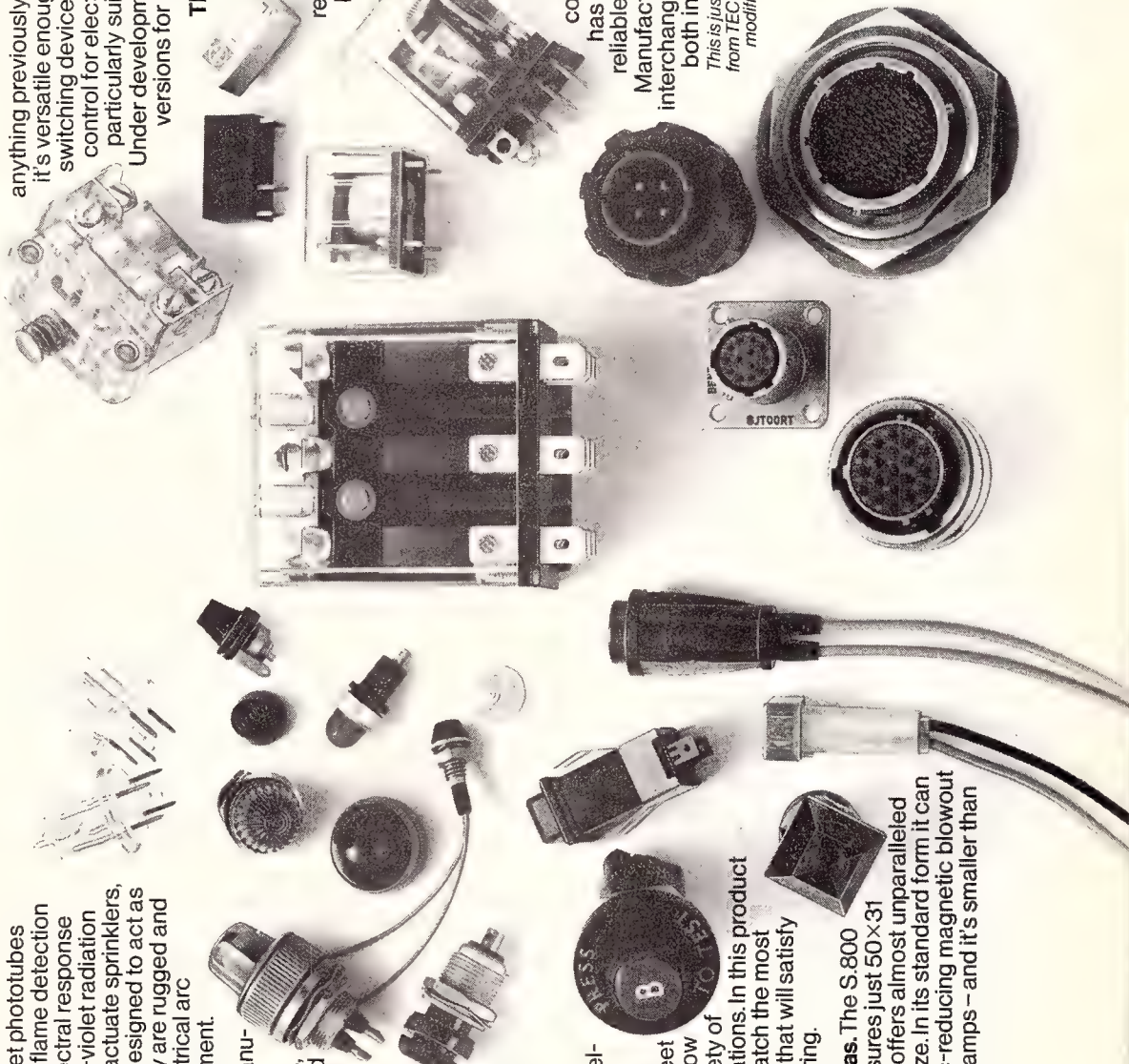
The very best connections. Nearly 20 years collaboration by Thom and the Bendix Corporation has enabled TEC to produce a range of rugged and reliable circular multiway LF electrical connectors. Manufactured in Britain, they are readily available and fully interchangeable to meet electrical and environmental needs both in the home market and world wide.

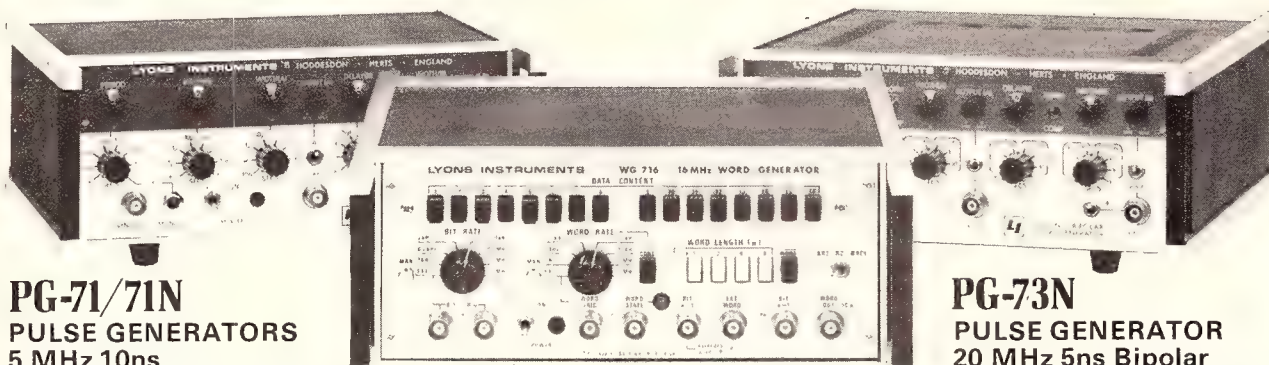
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True double pulser with very wide control ranges, independent for each channel. Dual pos or pos/neg 10V outputs with normal/complement facilities.

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the latest word in signal sources

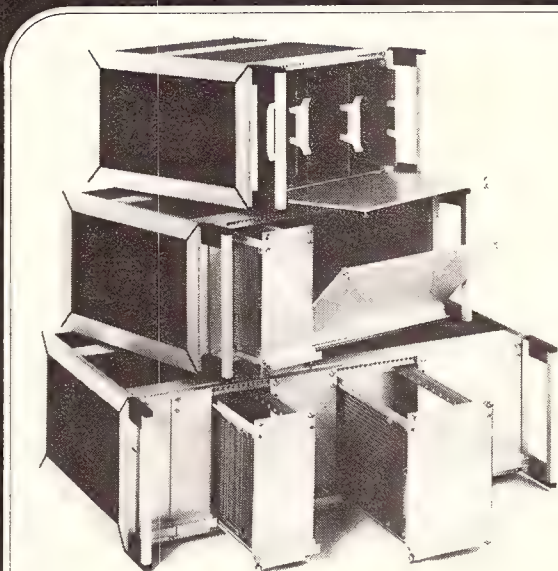
Full specifications and prices of the above on request. Ask for details also of other Interlab® low-cost instruments – distortion meter and sine/square oscillator for laboratory, test and education purposes.



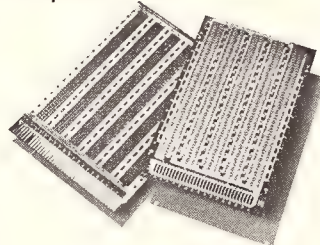
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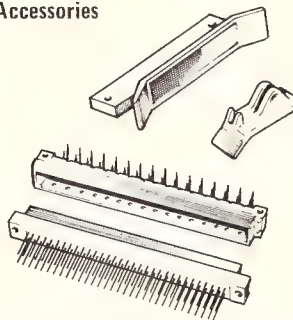
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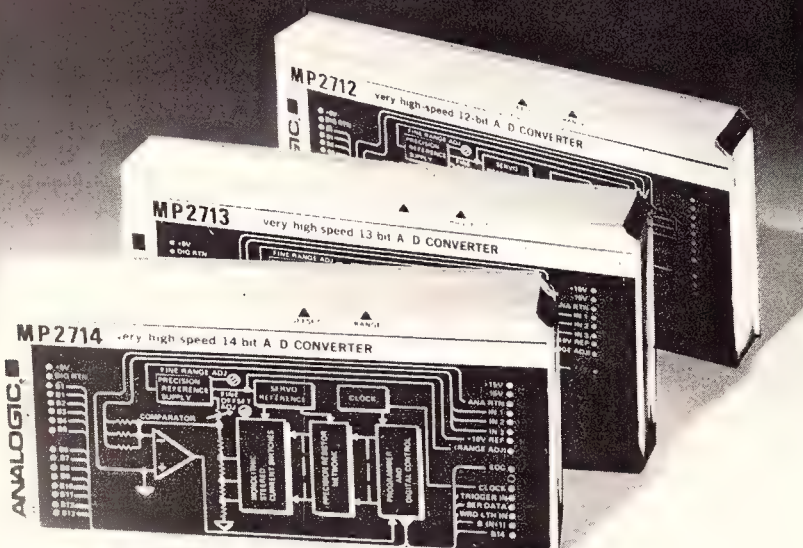
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Section **6** in our 1976 catalogue

EUROCARD SYSTEM. A CASE FOR EUROPE

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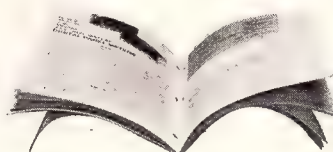
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Four full scale ranges, providing a 4 to 1 range sensitivity, enable the designer to choose the range best matched to the balance of his system. Built-in gain and offset adjustments eliminate external pots and assure that every unit shipped is calibrated to within a guaranteed accuracy specification traceable to the NBS.

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mN601. The microNOVA CPU.

It's a full-blown, 16-bit NOVA computer. Manufactured by Data General. And fully supported by NOVA software.

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The difference is, all that NOVA has been reduced to a single chip that measures only 225 mils by 244 mils.

Which was no small accomplishment.

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And for those who need more than a board, there's a fully-packaged 4K word MOS microNOVA mini. It comes with power supply and turnkey console. In 9 and 18 slot versions. Into which you can place as much as 32K words of RAM or PROM. And still have plenty of room left over for I/O.

There's even a microNOVA system specifically for program development. A complete system, with dual diskette drive, terminal and our RDOS-compatible Disc Operating System. Or you can use a Nova 3 system with RDOS. The best development software you can get.

And no matter which microNOVA product you get, you get to use NOVA software like FORTRAN IV. Software that's in use in over 20,000 installations all over the world. So you know it's going to work right the day you get it.

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Offices also in Birmingham, Manchester and Glasgow.

PRODUCT FOCUS

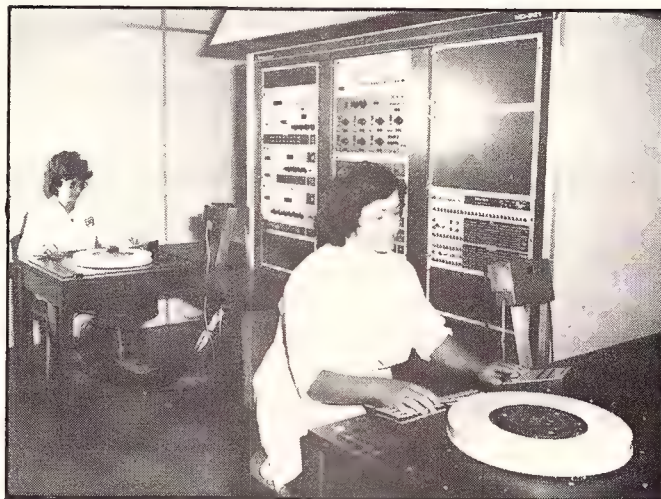
Advances in lsi technology are now reaching an interesting stage of development. The continuing reduction in circuit size coupled with increasing circuit complexity continues to be the aim of the lsi manufacturer as well as the attempts to obtain less power per chip.

The achievement of these features seems to be gained not only by improved circuit fabrication techniques but also by increasing ingenuity in circuit concepts. Here one can cite the case of I^2L which has undoubtedly brought bipolar technology once more into the arena to do battle with the mos technologies which have for so long dominated the lsi field. Injection logic is not so much a technology but more a circuit concept and can be fabricated using any standard bipolar process (provided the process does not have any gold doping in the substrate as this destroys the gain of the transistors).

The lsi market—especially in the custom design—is a flourishing one as manufacturers become aware of the advantages that lsi can bring to their designs. Many oem manufacturers are becoming concerned with the production of lightweight equipment or products which demand more complexity as well as trying to keep costs down. This is where lsi can prove its worth especially where large quantities of similar circuits are involved. The consumer market has taken advantage of lsi in such areas as washing machine controllers and video games.

Once the manufacturer has decided to commit his product to include lsi, the next step is to approach a custom design facility—unless there is an in-house one available. The next decision is the best technology to be used which will give the most flexible and economic solution.

The choice of technology available is a confusing one and it is dependant on the demands made upon the finished product as well as the economics involved. Watch circuits for example not only have space at a premium but also the power consumption. To date there are two technologies cmos and I^2L which are suitable for watch circuit fabrication. Watch lsi circuits have by no means reached a final standard. Large improvements are still to be made towards lower cost, better per-



LARGE SCALE INTEGRATION

In this month's product focus Elaine Williams looks at the lsi market and compares the technologies available to the custom designer as well as commenting on future developments

formance and more functions. However chips for use in data handling may make demands on the speed of the device rather than any physical advantages to be gained.

Choice in MOS

In mos technology alone there are a bewildering number of processes which can be used. MOS is the undoubted leader in the lsi market but is now being challenged by bipolar in some areas (see the European Solid State conference report on p61).

Each company has its own favoured brand of mos and refinements of basic processes. GEC Semiconductor uses p channel mos while GIM has an n channel process for some applications.

One of the first processes which became available was a p channel metal gate process. This is still a much used process for many applications but it needs a relatively high supply voltage, in the range of 20 to 27 V because of its high threshold voltage. These circuits are ideal for applications which require only a limited complexity

running at low speeds and where power dissipation is not a main consideration. The complexity is in the region of less than 100 transistors per chip.

To reduce the power consumption dynamic mos circuits were introduced. Although the testing of dynamic circuits is more difficult they have advantages of lower power dissipation per gate, relatively high speed of operation and high complexity of up to 10 000 transistors available per chip. However these circuits are intended for relatively high speed operation and do not function well at the lower frequency range as well as having a limited operational temperature range.

Much interest today by lsi manufacturers is being placed on silicon gate mos, sos and cmos with all the variations one could imagine. The replacement of the aluminium gate by silicon has meant that devices can be fabricated with lower threshold voltages which all serve towards producing circuits which run off lower supply voltages.

Another technology favourite which is available from many

manufacturers such as RCA, GECS, Intersil and Mullard is cmos which offers several good features. CMOS is virtually immune to noise, runs off almost any power supply and is an extremely low power consumption circuit. In the off state cmos draws zero current and even when operating at moderate speeds, a 100 gate logic array will draw typically less than 0.1 mW. At speeds comparable to that of bipolar circuits the dissipation may be as much as 20 mW per gate.

Although cmos incorporates a larger area per gate than many other processes (since it comprises both n and p channel devices and therefore also needs isolation) companies such as ASEA HAFO choose cmos since it can operate at high speed. Applications of the technology include rams, roms, shift registers and one and two chip microprocessors. Also because of their high noise immunity they are used in car ignition systems and other electrically noisy areas.

To overcome the disadvantages of increased space required by the technology some companies such as Mullard have attempted to eliminate the need for guard bands in the device. This has been achieved in Mullard's case by means of a local oxidation process which they call locos. This involves coating the silicon with a layer of silicon nitride and areas of this are removed where local oxidation is required.

This not only prevents the formation of parasitic mos devices but also reduces the stray capacitance between substrate and wiring and is a self aligning process. Other companies have similar processes as well as conventional techniques which employ stopper diffusions.

Advances in the silicon on sapphire materials and the processing technology has widened the market from pilot production for custom design to large volume cmos ics. Silicon on sapphire technology is most effective in cmos processing since sapphire is an excellent conductor and the inherent dielectric isolation eliminates parasitic capacitance from the substrate increasing the operational speed by about three to one and decreasing the power dissipation. Elimination of the guard bands can improve the packing density by a factor as much as

Above: Chips are tested by computer at GIM in Scotland.

Siliconix

The new series of Siliconix CMOS analogue switches is latchproof with no compromise in performance: they still feature low and constant ON resistance, full $\pm 15\text{V}$ switching capability and high OFF isolation.

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- Break-before-make action
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Our switch range offers 2-, 4-, 8-, 16-channel units with ON resistances between 70 ohm (2-ch) and 400 ohm (16-ch). Here are just two of the possible applications. If you are interested in a higher OFF isolation, we have developed an interesting switch. Write for more data today.

Siliconix the first name for Analogue Switches

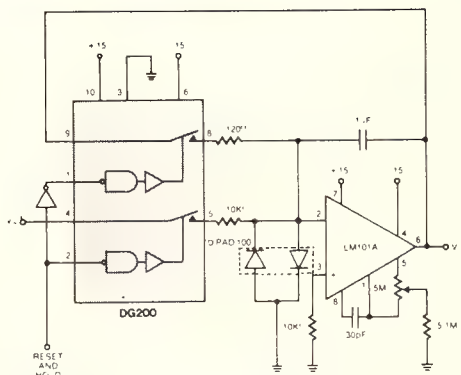
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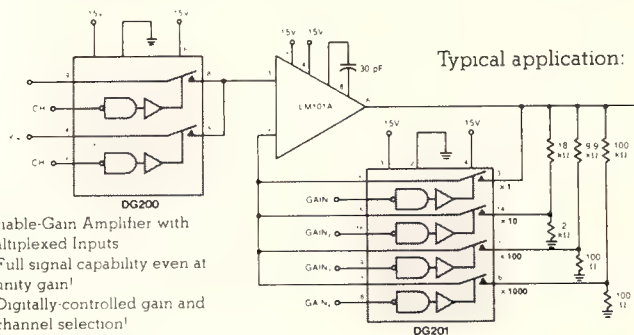
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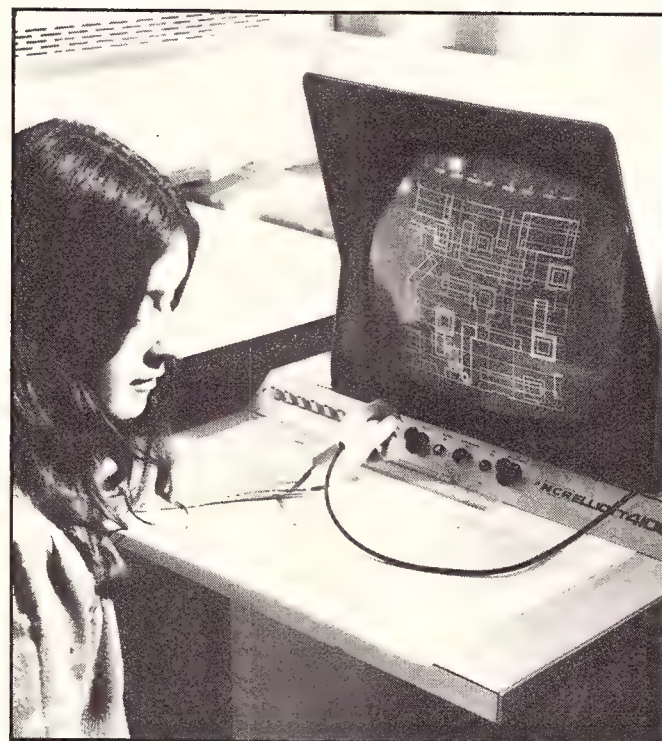
PRODUCT FOCUS

four to one. Union Carbide produces the sapphire crystals for such devices and the company says that the largest market for sos in commercial cmos technology are in the memory, counters, multiplexers and microprocessor fields.

One cannot ignore n channel devices either in the mos processes. The devices fabricated in this technology have both a low threshold voltage and supply requirements as well as offering small dimensions. There are several ways of fabricating these devices and ion implantation may be used in various parts of the process either to control enhancement thresholds of the n type regions, to increase the field inversion voltage for better isolation between devices or to produce depletion load devices. Either metal gate or silicon gate is used but silicon gives lower threshold voltages.

GIM has developed a simplified n channel process based on the metal gate. From this process the company fabricates lsi memory circuits. The company claims that this process is cheaper than the silicon gate process and GIM has made a 16 K rom using this technique.

Charge coupled devices also deserve to be mentioned here. These devices are essentially the same as the isoplanar n channel mos technology and are minority carrier devices. Their advantages are lower power, low noise and high circuit density. The applica-



Above: Compute aided design is used extensively.

Below: Comparison of chemical and ion beam etching.

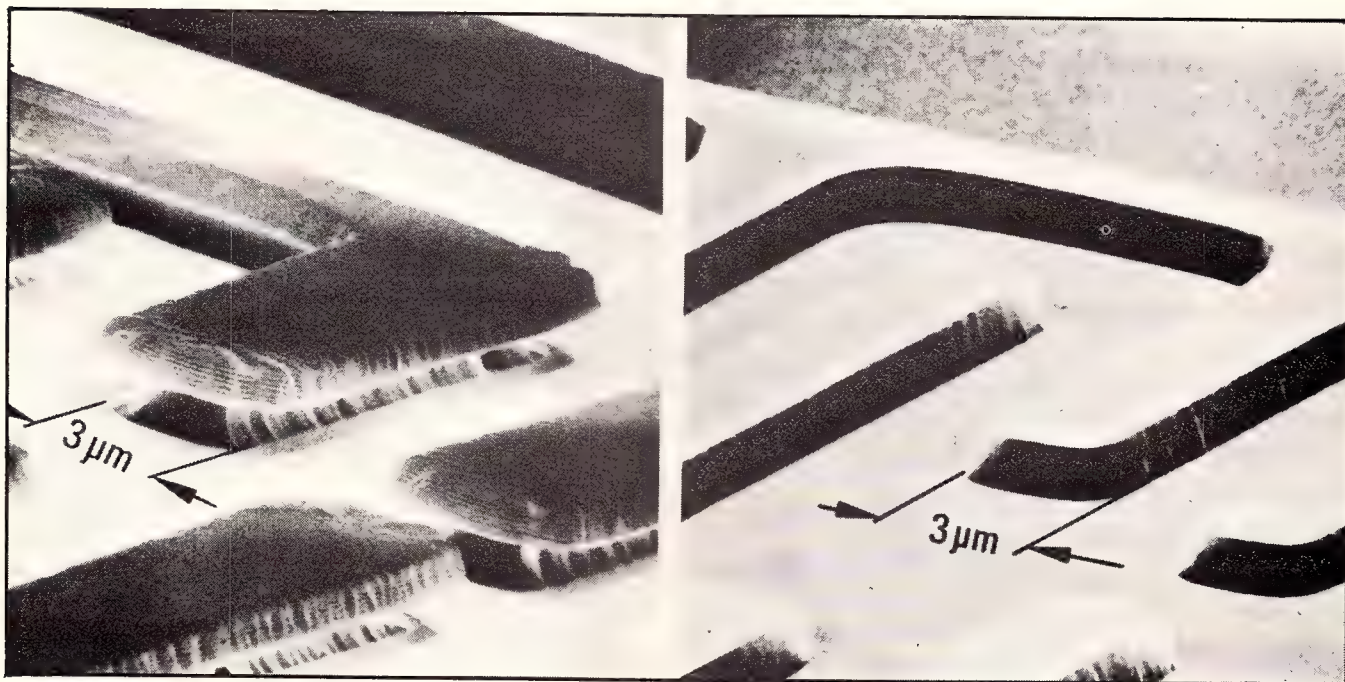
tions of charge coupled devices which are manufactured by Fairchild are in such fields as digital memories, charge coupled analogue shift registers and in image sensing. In fact the silicon nitride gates which are now used in some mos technologies were pioneered for charge coupled devices.

However while mos technology has been moving towards greater chip complexity and increased speed approaching that of bipolar circuitry, bipolar itself has not been standing still. Although bipolar technology is the acknowledged champion in the linear ic field, the means for bipolar to enter

successfully into the lsi market did not arrive until the advent of 1^2L . This has now placed bipolar technology into a strong position in some areas such as watch circuitry. Now with the characteristics of 1^2L being small gate size, reasonable speed and low power consumption, the limits of bipolar lsi has been stretched to the 1000 gates region while still giving the ability to combine linear, fast ecl, powerful driving stages and lsi on one chip.

Second generation circuits such as Plessey's Schottky 1^2L can now produce packing densities of 1000 gates/mm² and a speed power product of less than 0.05 pJ at low speed. In the memory area the bipolar circuits have usually dominated the high speed performance end of the market but the faster mos rams are forcing bipolar circuit designers to improve the performance of their circuits even more. For example Siemens 1K ram has an access time of 15 nsec and by using advances in technology such a passive isolation can often increase packing densities considerably. It is envisaged that it will be possible to permit the fabrication of 4K and perhaps 16K rams. Another technique which displays speeds better than conventional 1^2L is Schottky collector 1^2L and reduces gate size.

A technology known as collector diffusion isolation (cdi) which is manufactured by Ferranti is also an interesting con-



It's curtains for old eight-bit thinking and planning. The TMS 9900 16-bit microprocessor is the start of a new breed – more efficient, more powerful and economic. For the old fashioned 8-bit, time is running low. The 9900 family is winning the showdown.

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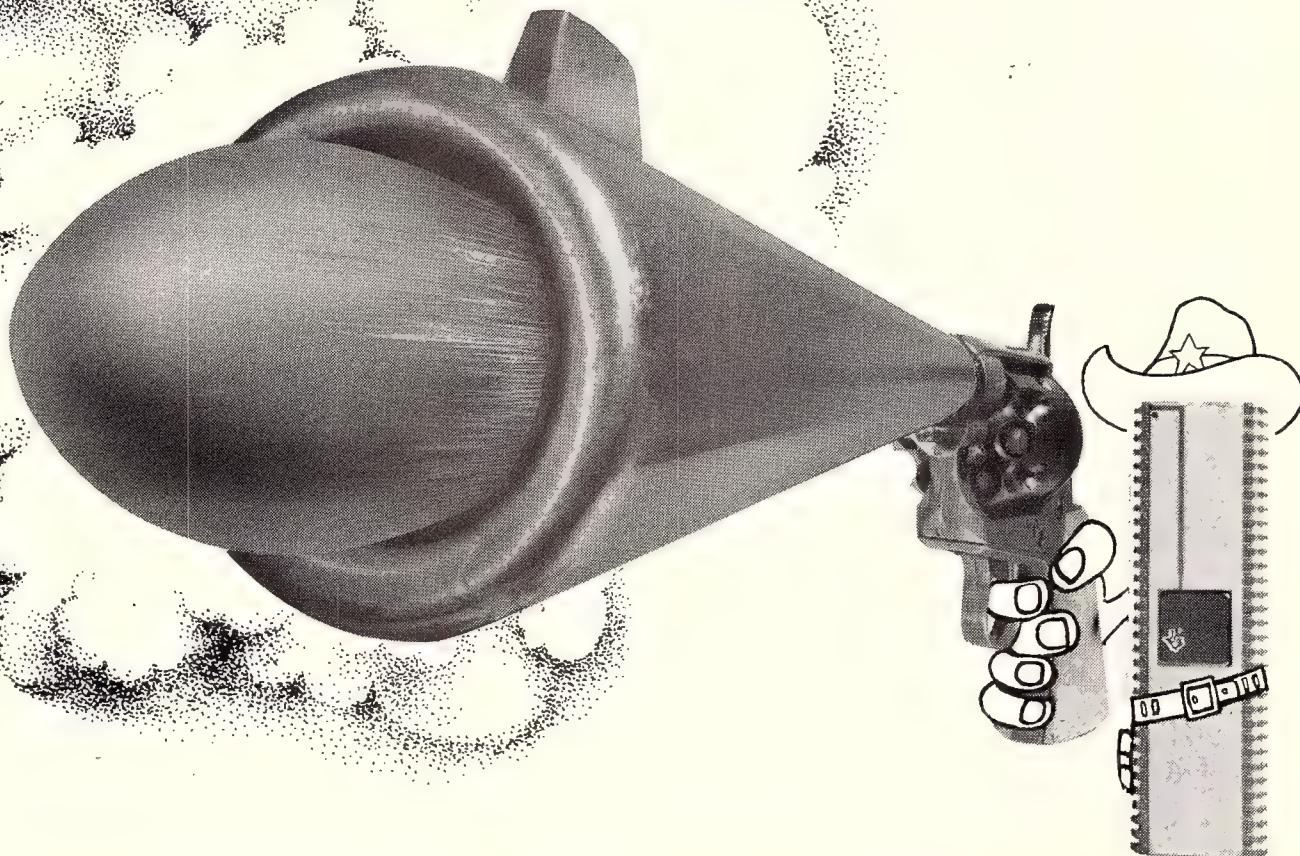
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The end of the two bit 8-bit.



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cept. The company uses this technology in uncommitted logic arrays for custom design. The feature of collector diffusion isolation which makes it applicable to the logic array is the fact that the bulk material of the ic can be used to distribute both the Vcc supply and the earth return current to all cells.

The ULA consists of 187 uncommitted cells which are complete except for the final aluminium interconnection pattern. When a customer specifies the logic function he requires the relevant interconnection pattern is generated to link up the required cells to provide the circuit function. This means that the uncommitted logic array can also be connected to form digital and linear functions on one chip. Signetics has a similar circuit for digital functions known as the field programmable logic array.

Looking ahead

There is little doubt that the use of techniques such as ion implantation and the future use of x-rays for lithographic purposes as well as ion beam etching will serve to improve the performance of lsi circuits even more. Ion implantation is in extensive use by most companies to control accurately doping levels within semiconductor materials.

Ion beam etching will prove to be a very interesting method of defining the structures on semiconductor chips. Siemens has been working on such a system and the company has found that ion beams are capable of producing structure spacings of 1 μm or less. However it then becomes necessary to utilise different methods than are normally used to create the structures which are defined by a photomask. This is because the chemical etching processes which are employed at the moment have an undercutting effect which is of the order of magnitude of the depth of the etch and cannot be tolerated as structures become smaller. The present Siemens process employs an ion beam which works mechanically like a sand blasting jet to cleanly cut out very fine chip structures.

The Argon ions required for the cutting are directed onto the photoresisted silicon chips. The advantage of this process is that the chip structures are smooth in contrast to chemical etching, and the angle of the sidewalls

has a uniform value of 65° .

Many companies are now actively involved in research into the use of x-rays for photolithography. In fact GIM are involved in a project jointly with the Massachusetts Institute of Technology to this end. They are developing an x-ray delineation technique which permits a factor of ten increase in chip density.

There is also a move towards the use of gallium arsenide material for the production of high speed devices (see conference report). Although gallium arsenide is used extensively in the production of optoelectronic devices it is likely to prove an interesting material for lsi purposes as well as its other peculiar properties. The optic properties it displays could be used in lsi applications since it may well be possible to optically couple all the devices on the chip so eliminating some of the metalisation layers.

Taking a broad look at the lsi industry we can see that improved bipolar ic technology has enabled bipolar rams to be produced with capacities comparable to the mos types. The calculator circuit has had a

profound effect on lsi technology and over the past few years the number of chips required for a calculator has fallen from six to two and single chip calculators (and microprocessors) are becoming commercially available.

The complexity of ics has grown exponentially. This has been achieved mainly by increasing the chip areas, by reducing line widths and by improvements in devices and circuits. Although many companies are studying x-rays methods and electron beams there is still a belief that optical methods can be improved upon. Results have shown that the exposure wavelength is only one parameter among many defining the resist contours after development.

In order to fabricate devices with reduced dimensions smaller resist dimensions will be needed and improved processes for pattern definition and doping. Classical diffusion processes or ion implantation can be used for semiconductor doping. Both vertical and lateral doping profiles need to be studied before the dimensions can be effective-

tively reduced.

The reduction of dimensions alone would not be sufficient to produce a higher packing density. The alignment of the different masks in the process is critical to the realisation of more complex chips.

The present situation between bipolar and mos is still a divided one. At the beginning of the 1970's mos devices were considered cheap but slow, while bipolar circuits were fast but rather expensive. However this situation is being challenged. The attributes of mos which makes the manufacturing process cheaper is the lower number of stages required.

There is only one diffusion step needed, the self isolating properties of the circuit elements are useful since fewer interconnections are required and they have a higher packing density. For the systems designer mos circuits have the advantage of high impedance and low power dissipation. However the advantages of bipolar are faster speed, high current handling and higher voltage gain coupled with low supply voltages.

In addition mos requires that precautions be taken to avoid electrostatic charges causing gate oxide breakdown which are not necessary in the case of bipolar circuits.

In the past few years changes have been occurring in the industry. CMOS technology has increased the speed of mos to nearly that of bipolars but the extra diffusion which is used in the process raises the cost. Also the cdi and isoplanar processes used in the bipolar technology have simplified manufacture by the elimination of one diffusion step and operating speeds are faster than that of mos or core memories. The future trends in the digital ic field will continue to be towards increasing complexity and faster operation with 1^2L reaching the density performance of mos.

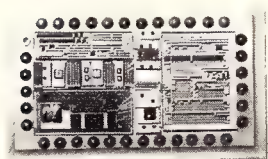
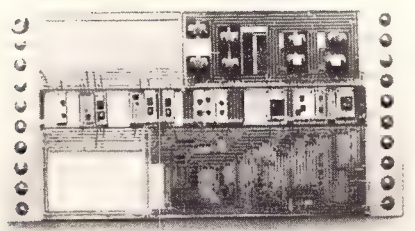
Ferranti's one chip μP illustrates increasing chip complexity.



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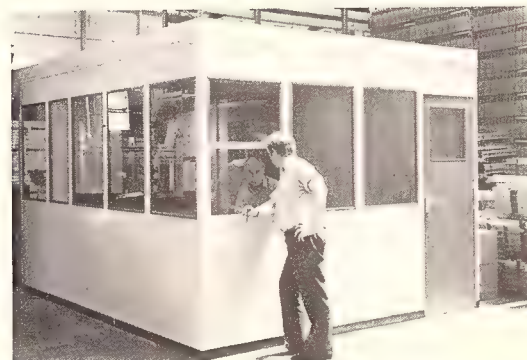
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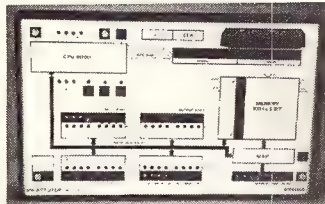
NEW PRODUCTS

GaAs fet amps

The AMT-15008M, GaAs fet, thin film, wideband amplifier covers over an octave from seven to 15 GHz, in C, X and Ku-bands. Gain is 30 dB, power o/p +7 dBm and the nf is 8,5 dB at 25°C. Development of seven to 18 GHz GaAs fet's to replace low noise twt's using an advanced thin film gold multi-refractory metal deposition on a ceramic substrate, with a 0,5 micron gate will be the next goal for the manufacturers. *Walmore Electronics, London.* **340**

Micro-tutor

The Microtutor 8080, is a fast, simple and cost effective way to develop an understanding of



μP's. The system is a full 8-bit micro-computer with an 8080 cpu, a 1k × 8-bit ram, an I/O, an interrupt instruction and status port. *Limrose Electronics, Northwich, Cheshire.* **341**

Pulse converter

The MC14408/09 binary to phone pulse converter sub-systems are designed to convert a 4-bit binary i/p code to a number of serial o/p pulses, corresponding to the value of the i/p code. Features include a *fifo* memory storing the last number dialled for ease of retention, a dialling capacity of 16

digit numbers and selectable dialling rates. *Motorola Semiconductors, Wembley, Middx.* **348**

Op-amps

Two versions of the MC1741 and MC1458 op-amps, feature low noise performance, have good peak noise voltages referred to the i/p <20 μV, measured in a bandwidth from 1 Hz to 1 kHz over a 10 s period. Source resistance is 100 kΩ. *Motorola Semiconductors, Wembley.* **342**

Converters

This modular converter takes as an i/p any dc-V in the range 20 to 35 V and provides o/p voltages of ±15 V at 100 mA and +5 V at 400 mA. Designated PUI1645, it provides power for ttl logic circuits and is ideal for converting rough dc source voltages. *Memory Devices, E. Molesey, Surrey.* **343**

Log ratio module

A recent introduction is the model 757, a complete temperature compensated, dc coupled, six-decade log ratio module. Log conformity is to within ±5% max. from 10 nA to 100 μA. The design is such that the symmetrical fet i/p stages, with bias currents <10 pA, allow either i/p to be operated within the specified dynamic range. *Analog Devices, E. Molesey, Surrey.* **344**

Input filters

A range of mains i/p filters designated FN322 are particularly effective for protecting equipments containing either

ttl or cmos circuitry. They are current rated at 1,3 and 6 A with 250 V rms mains working. The filters are screened from external electric or magnetic fields and have good attenuation characteristics, 40 dB over a frequency from two to 3 MHz. *Waycom, Bracknell, Berks.* **345**

RF connectors

The LP series of low profile rf connectors are designed for use on semi-flexible coaxial cable or similar cable. They feature a high performance at frequencies up to 18 GHz. Three sizes are available from 6,35 to 12,7 mm cable diameter and may be interchanged with tnc or type N interfaces. *Sealectro, Portsmouth, Hants.* **346**

8-bit dac's

The DAC90 is a monolithic 8-bit dac complete with internal voltage reference. Settling time to ±0,2% is 200 ns and the stability of the internal diffused resistors provide non-linearity of <±0,2% over the temperature ranges. Gain drift is ±50 ppm/°C, with temperature ranges from -25 to +85°C. *Burr-Brown Int., Watford, Herts.* **347**

Test system

To meet the need of testing the latest pcb's with their added complexities is the FF101A, an in-circuit component test system. The system can apply as many as 900 points to boards with circuit areas up to 444,5 × 647,7 mm. The system can be supplied with a 10 programme magnetic core memory for oper-

ator selection of a particular board for testing. *Microtesting, Alton, Hants.* **349**

μP supplies

These power sources, type EMP, are designed to provide low-cost power for μP based systems. The series provides the required flexibility for driving microcomputer, ram and similar logic systems. Other characteristics include remote sensing, parallel operation for the primary 5 V rails and sequencing. Ripple and noise figures are two and 5 mV pk-pk. *Coutant Electronics, Reading, Berks.* **350**

Power sources

A new programmable power supply, the HP6002A, provides a full 200 W o/p in the 20 to 50 V range. The unit operates both as a constant voltage and current source. Voltage o/p is adjustable from zero to 50 V whilst the maximum available current is automatically controlled. Conversely, current o/p is adjustable from zero to 10 A with the voltage being controlled to maintain the power boundary. *Hewlett-Packard, Winnersh, Wokingham, Berks.* **351**

Sequence circuits

These two decade sequencer circuits, the 9319 and -/20, provide the capability to sequence through ten states at a guaranteed clock rate of 35 MHz. Sequencing can be truncated synchronously or can be expanded to any number. The o/p are glitch-free, obtained by

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NEW PRODUCTS

using a decoded Johnson counter technique. The -/19 has standard ttl o/p that can drive ten ttl loads, the -/20 has dtl level o/p to facilitate interfacing with mos or cmos. *Fairchild Semiconductor, Barnet, Herts.*

352

UV prom's

Expanding the range of support circuits available for the F8 and advanced Z80 μ P families, has been the basis for the introduction of a 256×8 uv-erasable prom. The device has an access time of 550 ns for the MK3702T-1 and 1 μ s for the MK3702T-3. The device is fabricated using a p-channel Si-gate process with ion-implanted depletion mode loads. *Mostek UK, London.*

353

Keyboards

The E range of pushbutton control and signalling units are suitable for the construction of multi-way keyboards. Utilisation has been made of standard rotary switches with a contact operation of six 4 A c/o contacts at 110 V, or n/o or closed contacts at 220 V. Different colours and physical shapes are available. *Entrelec, Felpham, Sussex.*

354

IR-diodes

The XC1209 is an infra-red emitting diode with a typical power o/p of 1.5 mW at a forward current of 20 mA. IR radiation peaks at 940 nm. Maximum power dissipation at 25°C ambient is 75 mW and maximum forward dc current is 50

mA. Line width of the o/p is typically 50 nm, reverse current 10 μ A, rise time 300 ns and fall time 200 ns. *Distronic, Harlow, Essex.*

356

HV power supplies

The H16 hv power source is packaged in a double width module designed to the 6000 series specification laid down by UKAEA. The unit provides positive voltage of 5 kV at 50 μ A and is intended for use with semiconductor detectors. Stability is within 1%/hr and ripple <15 mV pk-pk. Output linearity is $\pm 0.1\%$ fs, accuracy of settling is ± 10 V and resolution is $\pm 0.05\%$ fs. *Brandenburg Nuclear, Thornton Heath, Surrey.*

357

Alphanumeric displays

Compact and complete with on-board electronics, these alphanumeric displays, designated the HDSP-2000, feature 3.8 mm high numerics offered in standard dip's. Each package has four digits which are end stackable. On-board are shift registers and externally programmable constant-current drivers, simplifying associated circuitry. Each character is formed with a five by seven dot matrix capable of displaying the full ASCII code. *Hewlett-Packard, Wokingham, Berks.*

363

Sweep oscillator

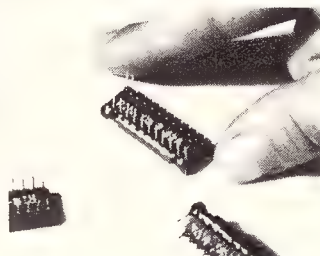
The model 554 is a compact sweep oscillator providing frequency coverage from eight to 12.4 GHz. Power o/p over the range is >10 mW. Frequency limits of the sweep can be set

to the nearest 10 MHz by two thumbwheel controls. The unit may be operated at fixed frequencies using the manual scan, or in slow single or fast automatic modes. *Flann Microwave, Bodmin, Cornwall.*

364

Stackable bargraphs

Announcing the introduction of a 12 segment bargraph using high efficiency GaAsP diodes spaced on 2.54 mm centres.



The devices are available in a 24-pin dip package and are end stackable with all cathodes and anodes available. *Bowmar Insts., Weybridge, Surrey.*

355

Indicators

The Rafix range of industrial pushbuttons, selector switches and indicators have fitted contact blocks with up to three c/o heavy duty contacts. Typical ratings are 10 A at 240 V ac and 5 A at 500 V ac. Various coloured lenses can be fitted to the push-button. *Londex, London.*

358

GaAs fet's

The first of a new family of GaAs Schottky barrier fet's the model HFET-1000, features a 14.5 dBm linear power o/p at 10 GHz. The nf at 10 GHz is

3.6 dB typical with a 6.9 dB associated gain; maximum available gain at that frequency is 11 dB. Designed for use in low noise amplifiers in the two to 12 GHz range, it incorporates a one by 500 micrometer gate. *Hewlett-Packard, Wokingham, Berks.*

359

Power sources

These high performance dc/dc power sources, provide 5 V, dual 12 and 15 V o/p from five, 12, 24 or 28 V dc inputs. Three and 5 W o/p power is available. The devices are ideal for applications requiring low o/p ripple and low noise, such as precision data acquisition modules and high performance op-amps. *Reliability Inc., Nenagh, Eire.*

366

Precision resistors

A new range of miniature and sub-miniature moulded wire-wound precision resistors, are approved to BS9113. The NPRB axial and NPRL radial styles are approved for the range 51Ω to 500 k Ω with tolerances from ± 0.05 to $\pm 1\%$. Tempcos. span 10, 15 and 20 ppm/°C with power ratings up to 2 W at 70°C. *Erg Comps., Dunstable, Beds.*

370

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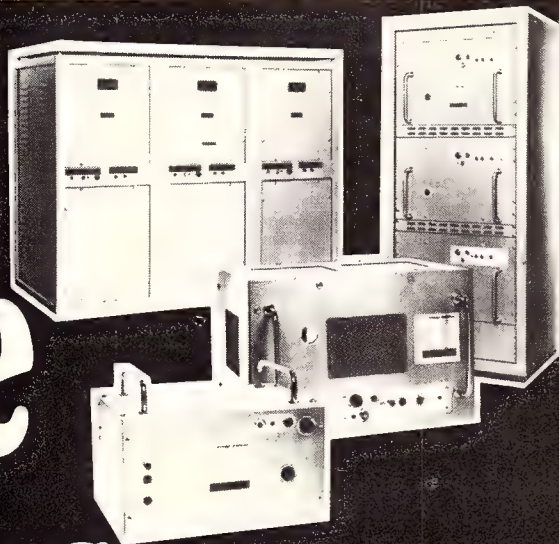
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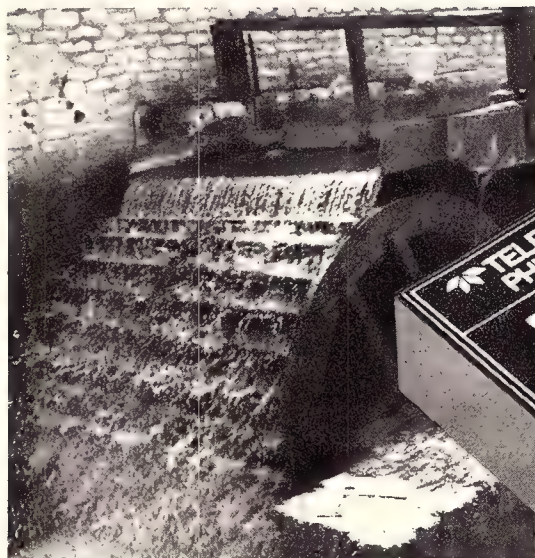
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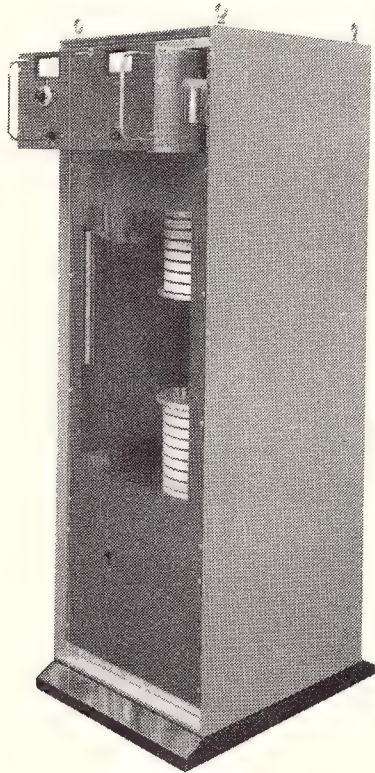
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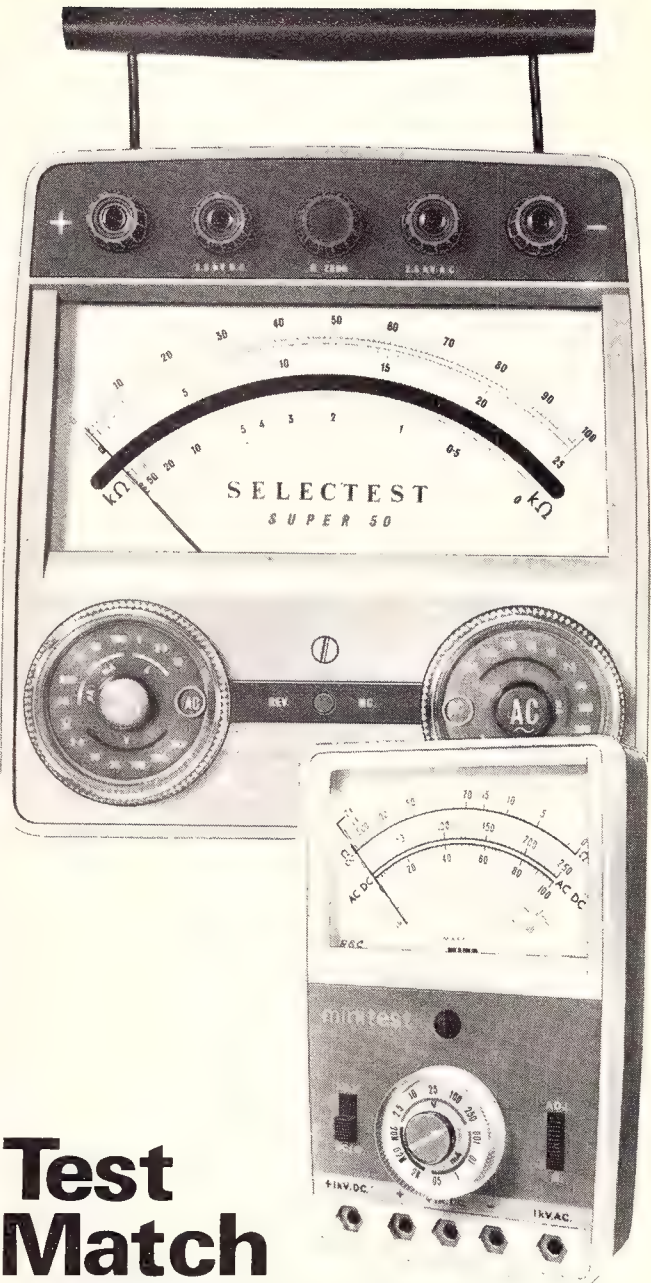
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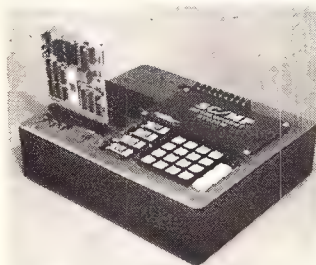
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NEW PRODUCTS

µP kit

This latest µP kit acts as the basis for a complete development system. The ISP-8P/301,



is based on the 8-bit SC/MP µP and allows simple programmes to be entered, in Hex code, into the memory. The kit is able to manipulate and display the programme and to control programme execution in a way that permits bugs to be corrected as they are discovered. *National Semis, Bedford.* **362**

Analogue multiplexer

A new series of four, eight and 16 channel analogue multiplexers manufactured with a dielectrically isolated cmos process has been designated the MX series. These units feature a high degree of immunity to i/p and power fault conditions. All models achieve transfer accurac-

ies of 0.01% at channel sampling rates up to 200 kHz for i/p signals ranging between ± 10 V. The dielectric isolation between channels holds crosstalk down by 86 dB. *Datel Basingstoke, Hants.* **365**

Signal processing

A new generation of signal processing modules with analogue and digital displays offer a possible 110 combinations giving a wide range of signal processing displays. Presentation is either one, two and three width modules for rack, case or panel mounting. Other modules offer signal averaging of pulsating signals, dual i/p square root extractors, signal ratioing and mass flow computing. *Gervase Inst., Cranleigh, Surrey.* **367**

µP systems

These two new µP systems form complete 8-bit microcomputers on only two chips, cutting the cost of equipment systems by a claimed 50%. Designated the PPS-8/2 family, both systems provide two chip microcomputers with cpu, one automatic serial and 16 parallel I/O ports, 16-bit interval timer, three level interrupt, clock circuit, 64 × 8 ram and either

1024 × 8 or 2048 × 8 rom. Both use the full instructions available in the standard PPS8 system. An inexpensive 3.5 MHz tv crystal is the only component required to complete the microcomputer, replacing five lsi circuits previously required. *Pelco (Electronics), Hove, Sussex.* **368**

Switching sources

The Melcher range of dc/dc and ac/dc switched mode power supplies are short circuit protected with foldback protection. Inhibit versions feature on/off switching from logic. The dc/dc range is designated SMR and offers 5 V supplies up to 12 A and 12 V up to 6 A. The ac/dc version, LSR15, gives 15 W o/p from five, 12, 15 and 24 V. Future versions will cover a 30 and 60 W range of o/p. *MEMEC, Whitchurch, Bucks.* **369**

Preamplifier

Designed to enhance measurements of low-level signals, the model 10855A preamplifier increases by a factor of ten instrument sensitivity. Minimum gain is 22 dB (24 dB typical) and operation comes from power sources of +15 V at 40 mA or from instruments with probe power output. Features of the

unit are its gain of 22 dB or greater from two to 1300 MHz, ± 1 dB flat response, 50Ω i/p and o/p impedances, fuse protection and reverse isolation of >45 dB. *Hewlett-Packard, Wincersh, Berks.* **371**

Optical fibre

Hytran T400 is a new optical fibre bundle sheathed in fluorocarbon Tefzel, making it suitable for use in avionics and hv systems. It is ideal for communications links up to 40 metres long and is designed specifically for use with inexpensive led's and coupling components. Attenuation is 400 dB/Km over 800/900 nm with a numerical aperture of 0.66. The range now caters for transmission distances up to 500 metres. *Pilkington PE, St Helens, Merseyside.* **372**

Memories

Three new 256 × 1 ram's, types GEF4720, -/20 V and -/20V/S1 are the latest additions to the Locmos series. The 4720 and -/20V are static devices with a power consumption of 5 µA. The former device has a supply voltage from three to 15 V and an access time of 550 ns. The latter devices range from three to 10 V. The -/20V/S1 is a speed

4 Digits



7734 Standard, 5 MHz. Frequency and count only.

5 Digits



7734S, 15 MHz. Frequency and count only.

6 Digits



7734U, 15 MHz. Frequency and count only.

7 Digits



7737 Standard, 50 MHz. Frequency and count. Period and Multi-Period. Two-Line Time Interval. Events per unit time.



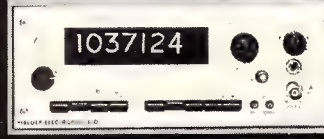
7734P, As standard and has slope selection on signal input.



7735 Standard, 15 MHz. Frequency and count. Period and Multi-Period. Two-Line Time Interval.



7735U, 15 MHz. Frequency and count. Period and Multi-Period. Two-Line Time Interval.



7737Y or Z fitted with serial or parallel b.c.d. output for printer.



7734Y fitted with serial b.c.d. output for printer.



7735G, As standard but with special contact timing facilities.



7735UY or Z fitted with serial or parallel b.c.d. output for printer.



7737A, 100 MHz. Frequency and count. Period and Multi-Period. Two-Line Time Interval. Events per unit time.



7734Z fitted with parallel b.c.d. output for printer.



7735Y or Z fitted with serial or parallel b.c.d. output for printer.



1000F Special version for telephone use.



7737A Y or Z fitted with serial or parallel b.c.d. output for printer.

NEW PRODUCTS

selected version with an access time of 400 ns at 5 V and 130 ns at 10 V. *Mullard, London.* **360**

Opto-isolators

The OPI 120, 15 kV opto-isolator uses a hermetically sealed sensor and led with conventional three lead transistor o/p. A high current transfer ratio is afforded, typically 70% being obtained. The sensing transistor offers 25 V capability and a continuous ON current of 50 mA. The GaAs led can withstand currents of 150 mA. Switching time is low at 2.2 μ s. *Norbain Opto-Electronics, Reading, Berks.* **361**

Trigger transformers

The PL9200 series of trigger transformers are low cost transfer units for high amplitude or long duration pulses without saturation. They are designed for trigger source isolation in half and full wave scr power control circuits including motor speed and incandescent lighting controls. *Bourns (Trimpot), Hounslow, Middx.* **376**

Regulator circuits

These two 'settable' micropower voltage detector circuits, the ICL8211 and -/8212 are cap-

able of measuring between two and 30 V. The -/8211 o/p is ON when the voltage detected falls below a desired value and similarly the -/8212 o/p is ON when the voltage rises above the required value. Both devices maintain virtually constant power supply currents, typically 20 μ A. The o/p of the -/8211 in its ON state is current limited to 7 mA, the o/p from the -/8212 is variable. *Intersil, Reading, Berks.* **377**

Camera tubes

A range of silicon intensifier target camera tubes, includes a family of low-bloom devices and a 12 mm tube for compact systems. The 4804/H family utilise a silicon diode array target and are offered in a selection of potting configurations. The C21199/P1 is a 12 mm intensifier target tube designed for use in compact tv systems. It measures 150 mm in length with a neck diameter of 17.5 mm. *RCA Solid State, Sunbury-on-Thames, Middx.* **373**

Isolators

Two new ranges of optically coupled isolators utilising GaAs ir-led's together with silicon phototransistors are housed in a

single 6-pin plastics dil package. The NSL150 and -/250 ranges have minimum isolation of 1.5 and 2.5 kV respectively and insulation resistance of $>10^{11}\Omega$. The coupled characteristics of these devices provide a high dc current transfer ratio of up to 20%. They have fast rise and fall times typically 2 μ s and low dark currents of 5 nA. *NSL, Altringham, Cheshire.* **374**

Timer-counters

Two new general purpose timer-counters, the TC311 and 314, offer bandwidths of dc to 10 MHz on two channels in both instances. The 314 has an additional channel spanning 20



Hz to 50 MHz. Features include a variable display time, a choice of store or follow modes and a high stability internal crystal. AC/dc coupling with an i/p impedance of 1 M Ω , i/p filters and attenuators etc, are available. Display time is variable between 0.2 to 5 s or held. *Gould-Advance, Hainault, Essex.* **381**

8k-ram's

This 8k nmos dynamic ram is pin compatible with existing 22-pin 4k memories. Known as the AMS7008, it features an access time of 125 ns and is cheaper per bit on a system level. *Di-An Data Systems, Stockport, Cheshire.* **382**

4k dynamic ram's

The 2680 family of dynamic n-channel mos 4k ram's, offers a 4096 $\times$ 1-bit word organisation. Designated types 2680, -/1 and -/2 they have maximum access times of 200, 270 and 350 ns and cycle times of 400, 470 and 800 ns respectively. Typical values of supply voltages are 12, 5 and -5 V. Refresh time can be carried out in 2 ms by performing a read cycle at each of the 64 row addresses. *Mullard, London.* **383**

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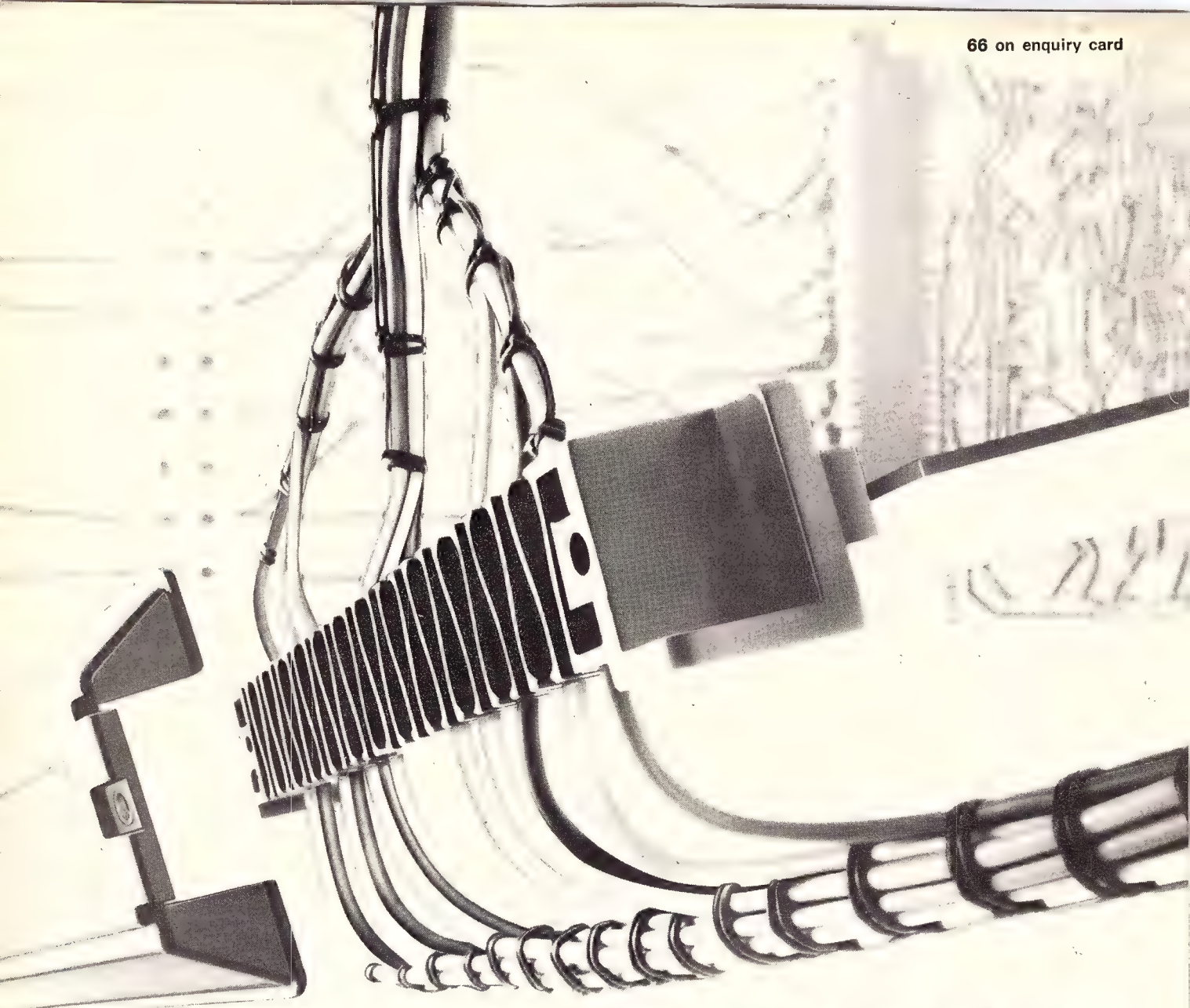
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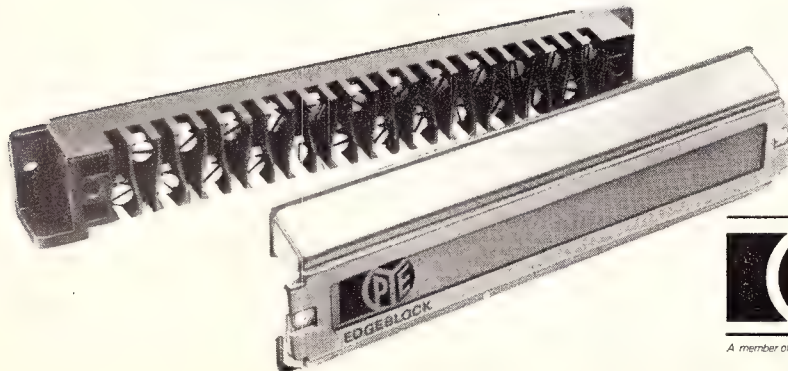
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NEW PRODUCTS

CMOS adc's

The ADC586 series is a cmos integrated adc available as eight, 10 and 12-bit units, housed in a 24-pin ceramic dil package. Temperature span covers -40 to +85°C. Power dissipation is low, typically <20 mW. Monotonic with no missing codes, this accurate series has a non-linearity drift of <2.5 ppm/°C and is low power ttl and cmos compatible. Conversion times are 1, 8, 6 and 24 ms respectively. *Hybrid Systems, Camberley, Surrey.* **375**

Digital multimeter

The model 3435A, 3½ dmm has a unique 'touch hold' probe, available as an accessory, that allows the user to 'freeze' the reading on the display. The unit covers a dc measurement range from 200 mV to 1,2 kV fs; an ac range from 200 mV to 1,2 kV rms fs over a 30 Hz to 100 kHz bandwidth. AC and dc current measurement range spans 200 µA to 2 A. The resistance range is 10 mΩ to 20 MΩ. *Hewlett-Packard, Winnersh, Berks.* **379**

RF amplifier

The model 500M provides coverage of the frequency range one to 600 MHz in the form of a low cost broadband linear amplifier. The unit boosts the o/p of signal generators, sweep generators or oscilloscopes by a nominal 27 dB. Capable of 0,5 W of linear Class A power, it will drive a constant forward power into any load from an open to short circuit. *ENI, Hitchin, Herts.* **380**

Light sources

Self-luminous light sources or 'microlights' consist of sealed borosilicate glass capsules having substantial wall thickness, coated internally with a phosphor which is excited to luminescence by Tritium gas. They are



available in a wide range of shapes and sizes and can be produced having brightness levels from 20 to 2000 µL. Colour conformity is either green, blue, yellow, orange and red emissive. *A Gutekunst KG, W Germany.* **384**

Broadband attenuators

These broadband attenuators for use to 18 GHz feature SRM-SMA connector interfaces. Four values are available three, six, 10 and 20 dB. VSWR is 1,23:1 maximum at 10 GHz and 1,35:1 at 18 GHz. Rated at 2 W average power and 500 W peak power they have sensitivity >0,001 dB/dB/W. *Sealectro, Portsmouth, Hants.* **386**

Amplifiers

These two vhf/uhf hybrid ic amplifiers cover the frequency range from 30 to 890 MHz. The model MC5120 has a voltage

gain of 20 dB with a nf of 8 dB. The model MC5121 has a gain of 26 dB with a nf of 7 dB maximum. *Dale Electronics, Camberley, Surrey.* **387**

DC/dc converters

The Powercard 15 W dc/dc converters are suitable for i/p of 24 or 50 V. A modular linear triple-o/p power source in the range Size 2 configuration features an o/p of 5 V at 1,5 A and ±15 V at 0,2 A. Also announced are adjustable linear stabilised supplies in two versions. The first offers a choice of voltages from 4,5 to 16 V and the second from 15 to 30 V. Current ranges are 0,5 to 10 A and 0,5 to 5 A. In switching power sources is a new triple o/p DOL unit giving 5 V, 20 A at 165 W; ±12 to 15 V at 2 A, or 24 to 30 V at 2 A. *ITT Comps., Harlow, Essex.* **388**

Rechargeable batteries

A number of technological innovations are incorporated in the new Pananica range of rechargeable nickel-cadmium batteries. There are six batteries in the range with nominal capacities at five hour rate varying from 3,500 mAh for the largest, down to 150 mAh at the other end of the range. A new construction is employed for the electrodes reducing the internal resistance of the battery. *Symot, Henley-on-Thames, Oxon.* **378**

Digital voltmeters

The model 8500A dmm is a bus orientated µP controlled measurement system capable of measuring dc-V, ac-V, dc/ac

current and resistance by the addition of plug-in modules in any available slot in the bus structure. DC voltage measurement and dc ratio are standard features. DC voltage is measured over five ranges from 1 µV to 1,2 kV with a basic accuracy of ±0,001%. AC voltage is measured with one of two options, the -/01 which is an average converter with an accuracy of ±0,005%, or the -/09 true rms converter with an accuracy of ±0,1%. With the ohms converter option -/02, four terminal resistance measurements from 10Ω to 100 MΩ fs can be made with an accuracy of ±0,003%. Option -/03 allows ac/dc current measurements to be made from 1 nA to 1,28 A. *Fluke Int., Watford, Herts.* **389**

Transducers

These two new pressure transducers, the XT21A and -/B are both available in ranges from 300 bar (4350 psi) up to 2000 bar (29 000 psi). Both units are small in size and feature a high frequency response, making them ideal for the measurement of dynamic pressures and transients. *Intersonde, Watford, Herts.* **395**

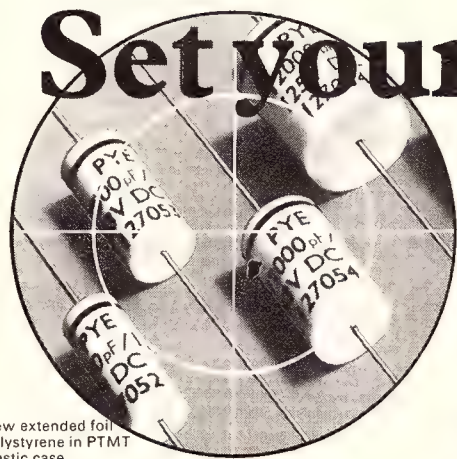
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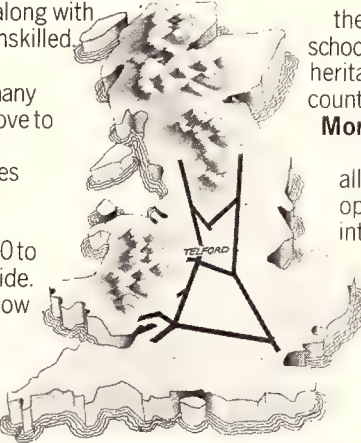
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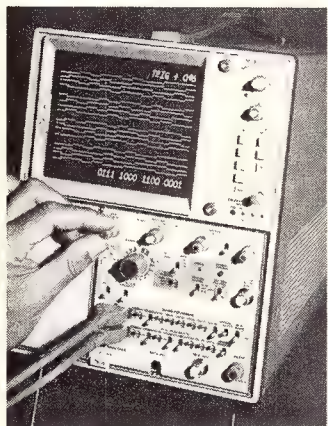
NEW PRODUCTS

Microcomputer board

A compact 254 × 161,9 mm single board computer using an 8080 μ P designated the QMS-80-1180, offers features including, 2k bytes of ram; full memory address decoding; built-in single step circuitry; RS232 and 20 mA serial interfaces and 1,5 k bytes of prom containing a comprehensive monitor programme. The board is constructed using mos and low power Schottky devices minimising power consumption and plugs into a single 2,54 mm pitch edge connector. *Quarndon Electronics, Derby.* **385**

Logic analyser

Designated the 7D01, this logic analyser is a plug-in for the 7000 series of 'scopes. The unit



has formattable 16 channel data acquisition, 4096-bit memory capacity and 16 channel word recognition capability. Features include a 15 ns asynchronous timing resolution, high im-

pedance active probes, trigger marker and cursor and a pre-triggering feature for viewing faults before the trigger. *Tektronix, Harpenden, Herts.* **392**

Timers

This surface mounted timer is offered with all time functions voltages, etc. Time ranges span 0,15 s up to 60 hrs and due to its ease of fixing lends itself to conditions where vibration is experienced. *Broyce Control, Brierley Hill, W Midlands.* **393**

Mini printer

The National range of spark-erosion printers are available in column widths of 15, 21, 32 and 40 columns and fully alphanumeric with symbols and graph capabilities. Print-out is by a 7 × 5 matrix at a speed of two lines/s. *Spectronics, Poole, Dorset.* **394**

Op-amp sources

This low profile power supply module has been designed for energising op-amps or other devices requiring a balanced dual rail supply. Identified as the Op-Amp card supply, the unit operates from ac mains i/p in the range 100 to 130 or 200 to 260 V and delivers a balanced dc o/p adjustable over the range ± 12 to 15 V by means of a preset control. Maximum load current is 250 mA on each rail, with both load and line regulation $> 0,02\%$. *Weir Insts., Bognor Regis, Sussex.* **397**

Plug-in lcd's

The Polaris line of 3 $\frac{1}{2}$, 4, 4 $\frac{1}{2}$, 5, 6 and 8 digit displays, 12 hour

clock and 16 segment alphanumeric field effect lcd's, are available in a choice of either reflective or transmissive modes. The low power requirements, 2,5 to 24 μ W are ideally suited for portable equipment. The displays are cmos and mos compatible offering wide viewing angles, up to 110° with a 20:1 contrast ratio. *IEE, Van Nuys, California.* **398**

EPROM eraser

A new range of powerful uv-lamps and accessories for erasing prom's offer intense short wave capability which shortens erasure time. The S-52T is based on an ozone free grid tube with a rated life in excess of 10 000 hrs. It features a timer assembly and holding tray with conductive foam liner and will erase up to 16 chips in seven minutes. *Ultra-Violet Prods., Winchester, Hants.* **390**

Optical cables

These cables suitable for a wide variety of applications, are made in lengths up to 1 km, having an attenuation of around 5 dB/km at 850 nm with rates up to 200 Mbit/s at current repeater spacings. Up to eight optical cores, or a combination of cores and conductor wires are available. *STL, Harlow, Essex.* **391**

Modular keyboards

The RC72 system can provide up to 30 positions both horizontally and vertically and will accept a complete range of switches, lampholders and snap-in covers. Either conventional or contactless switches, operating

between 4,5 and 27 V, can be supplied, with the latter incorporating Hall effect ic's obviating bounce and ageing problems. The o/p comprises two uniphase signals from open collector transistors, simplifying the design of encoding systems or alternatively a 2 μ s Schmitt trigger derived o/p pulse is available. *EES, London.* **401**

Pushbutton switches

The series 05 offers either led or incandescent lamp illumination devices. The product is available in both single and dp with n/o contacts. The series is rated at 0,25 A at 125/250 V ac. The unit accepts a T1 $\frac{3}{4}$ wedge base lamp or red, green or yellow led's. *Licon Electronics, Portsmouth, Hants.* **402**

Hybrid regulator

This new hybrid regulator subsystem provides a full 5 A of regulated power at 5 V with built-in short circuit and safe area protection. The system, known as the 78HO5KC, offers the advantages of a monolithic regulator at current levels not previously obtainable. *Fairchild Semis., New Barnet, Herts.* **400**

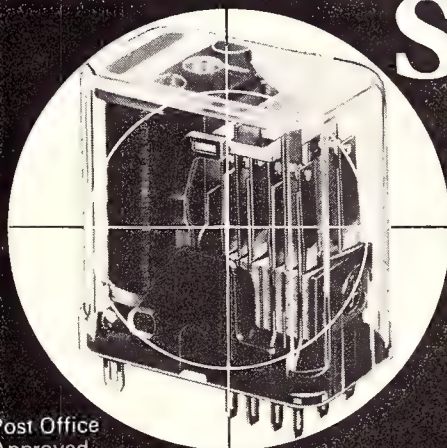
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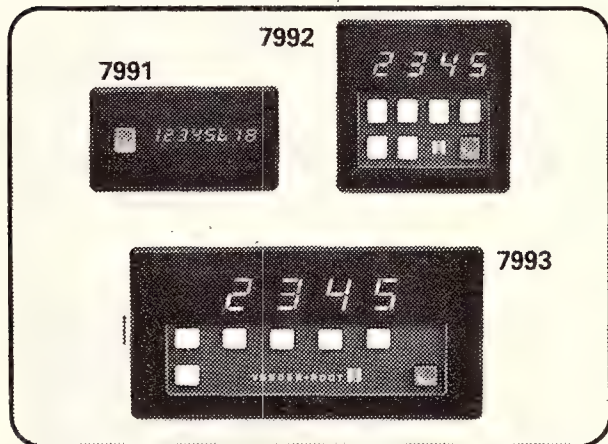
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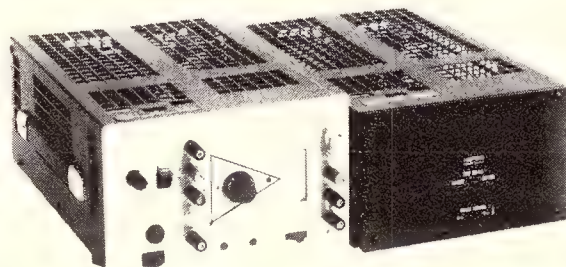
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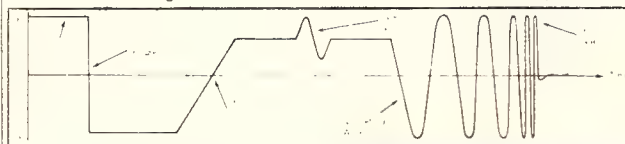
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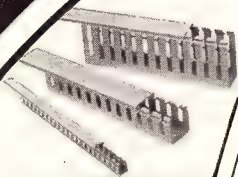
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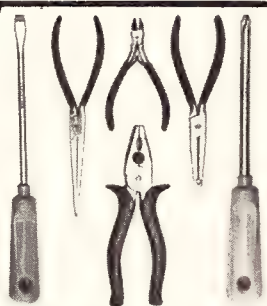


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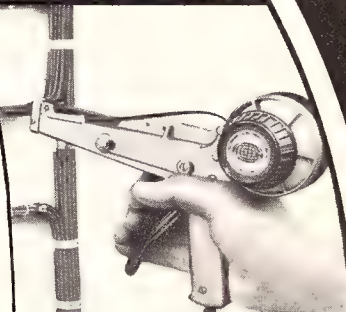


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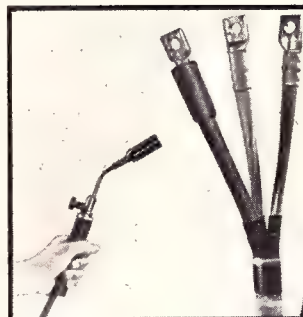
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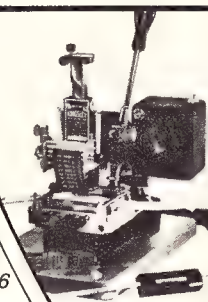
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How can you pick the smartest microprocessor system with an inadequate evaluation kit?

You can't. But there are plenty of companies that want you to try.

With the AMI 6800, it's a different story. Look at the chart

comparing our new EVK 300 evaluation and prototyping system with theirs. See what you've been missing?

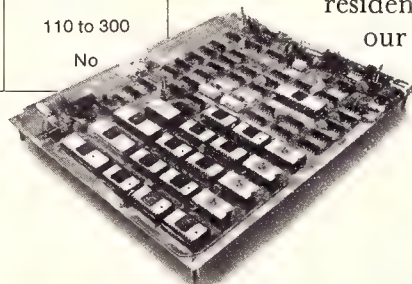
FEATURES	COMPETITORS—TOP OF THE LINE			
	AMI	MOTOROLA	INTEL	FAIRCHILD
Model Designation	6800 EVK 300	6800 MEK 6800	8080 SDK 80	F8 F8S
Board Size	10.5" x 12"	6" x 9"	6.75" x 12"	8" x 10"
Built-In EPROM Programmer (UV Erasable)	Yes	No	No	No
RAM Supplied (Bytes)	1024	256	256	1024
ROM Supplied (Bytes)	2048	1024	0	1024
EPROM Supplied (Bytes)	2048 (UV Erasable)	0	1024 (UV Erasable)	0 (Sockets for 2K Bipolar Fuse Link)
I/O Lines (Parallel)	58	16	24	16
I/O Interface (Serial) • RS232C • 20 mA Current Loop-TTY	Yes Yes	Yes Yes	Yes Yes	Yes No
Provisions for Slow Memory	Yes	No	Yes	No
Power Requirements	+5 VDC @ 3.5A +12 VDC @ 0.035A -12 VDC @ 0.15A -50 VDC @ 0.035A (For EPROM Programming Only)	+5 VDC @ 1.0A +12 VDC @ 0.1A -12 VDC @ 0.05A	+5 VDC @ 1.3A +12 VDC @ 0.35 A -10 VDC @ 0.20A	+5 VDC @ 2.5A +12 VDC @ 0.5A
DMA Modes	3	0	1	0
Interval Timer	Yes	No	No	Yes
Fully Buffered MPU Lines	Yes	No	No	No
Monitor Commands	10	5	6	6
Built-In Software Utility Routines	23	0	2	7
Breakpoints • Print • Snap-Shot	Yes Yes	Yes No	Yes No	Yes Yes
Clock • Crystal Controlled • Alternate Variable Frequency	Yes Yes	Yes No	Yes No	No No
Baud Rate • Selection Range • Crystal Controlled Independent of System Clock	0 to 19,200 Yes	110 to 300 No	75 to 4800 No	110 to 300 No

To begin with, on-board EPROMs make the difference between a meaningful tool and a hobby toy. Without them, program development is cumbersome and very expensive.

Then there's the on-board EPROM Programmer. It adds to the cost of the EVK 300. But without it, you pay a much higher price for EPROM programming.

And we give you another exclusive bonus: AMI 6800 Tiny Basic. This high-level interpretive language, derived from the standard Dartmouth Basic, comes to you free when we receive your EVK 300 guarantee.

You'll find plenty of other essential features that the others don't feature at all. So compare. Then call your local AMI sales office, distributor or representative, and ask to see our EVK 300. (He also has an unassembled kit with one EPROM, and a basic kit with none.) Or if you prefer, you can talk direct to our resident assembler at our Swindon design centre.



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Telephone: 771-4408

Omni-Ray GmbH, Nettetal 1-Breyell
Telephone: 4548 Telex: 854245

Mikrotec GmbH, Stuttgart
Telephone: (0711) 228 027

NEW PRODUCTS

Modular power sources

These encapsulated mains i/p power supplies offer a dual o/p fully stabilised for use with op-amps and other analogue devices. The D12-250 provides ± 12 V o/p with 250 mA current/channel. The D15-200 provides ± 15 V at 200 mA. Both units are overload protected, the foldback circuitry allowing approximately 150 mA under short circuit conditions. *Cliffpalm, Luton, Beds.* **404**

12-bit adc

This new successive approximation adc performs complete 12-bit conversion in 2 μ s. Designated model ADC-EH-12B3, it is claimed to be the industry's fastest 12-bit device. Power consumption is 2.3 W and operating voltage is ± 15 and $+5$ V dc with a gain tempco of ± 30 ppm/ $^{\circ}$ C. *Datel, Basingstoke, Hants.* **405**

16k rom

Designated the S6831, series A/B and C, these 2048 $\times$ 8 n-channel Si-gate depletion load rom's have an access time of 450 ns and consume 150 mW of power. They are claimed to be the fastest currently available. The access time is maintained over a capacitive load up to 130 pF on the output. *AMI Microsystems, Swindon, Wilts.* **406**

Push button switches

A new design of illuminated push-button switches for pcb mounting is available in various types of switching configurations, including a two c/o version. Switches are available with locking or non-locking (momentary) action and will take 12 or 24 V lamps, (T4.6 size). Lens are provided with coloured inserts and various markings. *Colstar, London.* **407**

Power supplies

These encapsulated power sources are designed for pcb's. They eliminate the problems of volt-drops along power distribution buses and the need for remote sensing. Four units are available PU25, ± 15 V ± 25 mA; 1520, ± 15 V ± 200 mA; 5050, 5 V 500 mA and 5100, 5 V 1 A. *Computing Techniques, Billingshurst, Sussex.* **408**

Oscilloscope

This 250 MHz portable 'scope provides at the probe tip, the gain and bandwidth needed for measuring mV level signals at sweep rates of 1 ns/div. The 475A can accurately examine transition times to an accuracy of $\pm 1\%$. Features of the unit include, a variable trigger hold-off, push-button trigger display, automatic scale factor indicators and an optional battery pack. *Tektronix, Harpenden, Herts.* **409**

Wire wound trimmers

The KDL-ADT05 is a rugged sub-miniature potentiometer encased in a

TO-5 can. The resistance range spans 15 Ω to 15 k Ω at a standard tolerance of $\pm 10\%$. Power rating is 0.5 W at 40 $^{\circ}$ C over a temperature range of -55 to $+125^{\circ}$ C. Tempco is < 500 ppm/ $^{\circ}$ C between 15 and 47 ohms. *Kenure Developments, Camberley, Surrey.* **410**

Microtutor

Based on the CDP1800 series of μ P, with 256 bytes of ram, this tutor may be used as a basis for developing cosmac systems. The μ P concepts are demonstrated by sample programmes which are loaded into the tutor via the eight manual i/p switches, with all system signals being registered on a two-digit hexadecimal display. *Yes Electronics, Harlow, Essex.* **411**

IC sockets

A new, low profile, low cost ic socket, designated the ICL series, occupies the minimum of space on pcb's. The device is specifically designed for use with automatic insertion machines and wave-soldering systems. *Astralux Dynamics, Colchester, Essex.* **412**

Frequency system

The self contained model 640 system, forms a complete network analyser for magnitude measurement of transmission, (gain or Loss) and reflection, (return Loss) from one to 1500 MHz in one continuous sweep. *Aveley Electric, Chessington, Surrey.* **413**

Megohm resistors

The Eltec range of very high megohm resistors have values from 10^6 to $10^{12}\Omega$. The model 102 and 104 are small in size and have standard tolerances of ± 2 to $\pm 20\%$ with 0.02 pF shunt capacitance and 0.5 dB noise figure (1 V bias). *Rofin, Egham, Surrey.* **414**

Reed switches

These two sub-miniature reed switches are designated types MRC3 and 4. They find particular use in keyboards, diode relays, scanners, etc. Features include operation to 1 kHz, a constant ampere turn operating value, low bounce and zero chatter on release. Maximum contact rating is 10 VA with a maximum current carrying capability of 1.5 A. *Tranchant Electronics, Hampton, Middx.* **415**

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C556 through C563

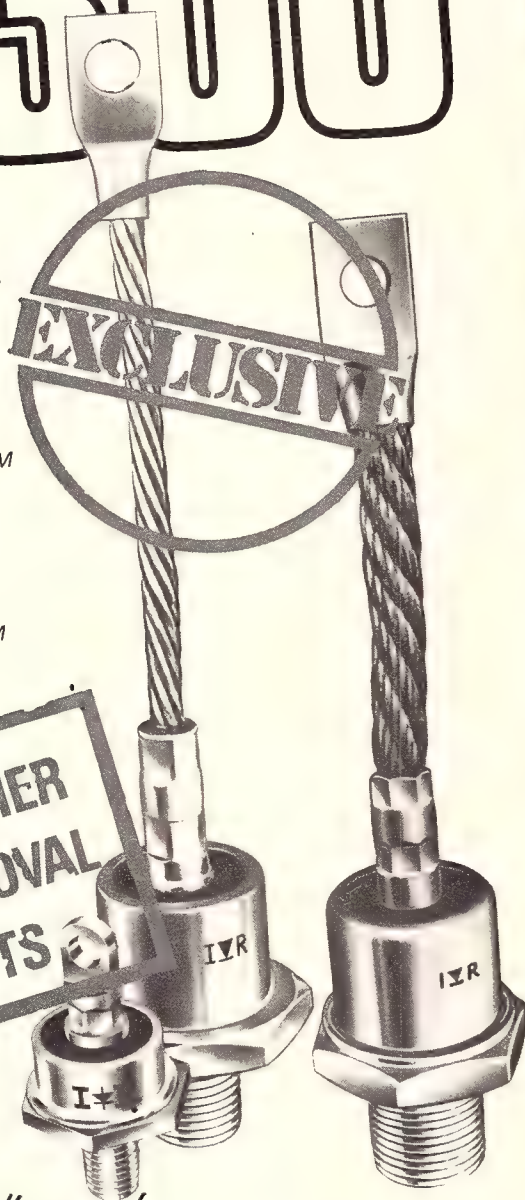
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250 Ampere 200-1000V_{RRM}
C564 through C571

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C572 through C579

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IF YOU CAN READ AN IC DATA SHEET YOU CAN USE THE NEW TERADYNE J401

Until now, the complexities of test programming have kept all but a few specialists from using IC test systems. Everyone else had to queue up at the programmer's desk or do without the kind of information that was really needed.

Now there's a J401. A fully programmable test system for T²L ICs with up to 24 pins, complete with built-in CRT, printer, and mag tape unit, that any engineer can learn to use in minutes.

For IC producers this means immediate access to vital process control information. For IC users it means the data necessary to choose components and vendors intelligently. And the ability to extract from field returns the information needed to improve product quality and yield.

The performance and flexibility of a large, computer-operated test system.

The J401 delivers the flexibility ordinarily associated only with larger, more expensive systems. It can datalog any forced or measured function and it can generate an x-y plot of any two parameters. The system also operates as a high throughput go/no-go tester for the production line or incoming inspection.

Product data fast.

Higher product yield.

For the semiconductor manufacturer, the easy-to-use J401 allows errors to be spotted before they can begin to multiply. QC engineers can use it to evaluate devices, determine test margins, and check device lots.

The electronic equipment manufacturer will find the J401 useful in monitoring vendor-to-vendor and lot-to-lot variations.

It enables him to spot device characteristics that could be contributing to problems. And QC personnel can use the system to analyze failures and reduce service costs.

A system for meeting the real objectives of incoming inspection.

The J401 gives you fast go/no-go testing with an important difference. It gives control over the way devices are tested. By pushing a few keys you can change test conditions, bin out top-quality ICs, or have data-logging to support returns. All in seconds. This is incoming inspection as it should be.

It's a Teradyne.

Each J401 is built for hard use on the factory floor. Each is supported by Teradyne's ten-year circuit module warranty, a telephone trouble-shooting service, and a world-wide field service backed up by local parts stocking centers.

For complete information on the J401, write:
Teradyne Ltd., Clive House,
Queens Road, Weybridge, Surrey.
Telephone: Weybridge 51431
Telex: 929809

85 on enquiry card

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NEW DATA

The book, **Principles of digital data transmission** by Dr A P Clark, £7.50 is written for engineers involved with the design and development of data transmission systems. *Pentech Press Ltd, Plymouth.* **251**

Recently published by Oxford Instruments is a new six page brochure describing the Newport series of **electromagnets**. *Oxford Instruments, Oxford.* **252**

An introduction to predetermined **motion time systems** has been prepared by the CBI, TUC and DoE on systems of measuring work. *HMSO, London.* **253**

Two guides on the selecting of **proms** and microprocessors prepared by the Pro-log Corporation is available from *Technitron, Camberley, Surrey.* **254**

The book, **Electronic Alarm projects for the home constructor**, £2.95 could help you to protect your home against burglary. *Newnes Butterworth, Sevenoaks, Kent.* **255**

Filtering in the time and frequency domains, £18.95 by Blinichikoff and Zverev provides a comprehensive reference on filtering techniques for electronic engineers. *John Wiley and Sons, Chichester, Sussex.* **256**

Leaflets are available on the model 4500 and 4050 video **display terminals** available from Delta Data Systems for programme development work. *Delta Data Systems, Welwyn Garden City, Herts.* **257**

Included in two shortform catalogues are details of a range of **boot mount-**

ings for no hole fixing of whip aerials on vehicles and a illustrated listing of a range of helical aerials for portables. *Panorama Radio Company, London.* **258**

Information is available on the Hall Thermotank range of **refrigeration** products. *Hall Thermotank, Dartford, Kent.* **259**

A **wallchart** is available from Fothergill and Harvey on the insulation properties of the company's tygadura range of wire and cable. *Fothergill and Harvey, Littleborough, Lancs.* **260**

A four page data sheet from Gould Advance describes the SG2000 **rf signal generator** which is a low cost general purpose instrument with a frequency range of 160 kHz to 230 MHz. *Gould, Hainault, Essex.* **261**

A full colour broadsheet details a range of **safety** and hygiene products specially developed by Russell Kirby for use in the factory environment. *Russell Kirby Ltd, Liverpool.* **262**

Motorola has published a 566 page **cmos** data book as an addition to the semiconductor data library. *Motorola, Wembley, Middx.* **263**

A publication from Bell and Howell concerns the unigraph which is a custom built **recording system** from a variety of applications including medical research. *Bell and Howell, Basingstoke, Hants.* **264**

A new catalogue from Schaevitz gives details of ranges and performance characteristics of the D series of **lvdt displacement transducers**. *Schaevitz, Slough, Berks.* **265**

The 1976 Synerjy directory contains information concerning articles, books and government reports published in England. *Synerjy, New York, U.S.A.* **266**

A catalogue is available from Vero on its ranges of **packages** and enclosures. *Vero, Eastleigh, Hants.* **267**

The Westinghouse industrial and government tube divisions' complete line of **display devices** for a variety of applications is covered in a 22 page catalogue. *Westinghouse Electric, Windsor, Berks.* **268**

Brochures are available on the range of maxon **dc motors** marketed by Trident Engineering. *Wokingham, Berks.* **269**

Dow Corning produce a Product news **publication** which describes the applications of the company's glass products. *Dow Corning, Brussels, Belgium.* **270**

The designs department of the BBC has produced a booklet which describes the **equipment** available to British industry for commercial exploitation under a manufacturing licence agreement. *BBC, London.* **271**

A 429 page data book on high reliability **integrated circuits** and discrete power devices is available from RCA. *Sunbury-on-Thames, Middx.* **272**

The Sel 32 software is described in a brochure from Systems Ltd along with the minicomputer, the Sel 32/35. *Systems, Croydon.* **273**

An illustrated digest catalogue is available from Beckmann which contains information on a selection of **analytical instruments** including

spectrophotometers. *Beckmann-RILC, Glenrothes, Scotland.* **274**

Soldering is the subject of a set of leaflets by Greenwood which contains details of the range of soldering equipment the company markets. *Greenwood, Reading, Berks.* **275**

AviQUIPO has produced a brochure which explains the **services** the company has available in the British marketplace. *AviQUIPO, Maidenhead.* **276**

An application note that describes the use of the HP1620A **pattern analyser** in oscilloscope based trouble shooting of digital instruments is now available from Hewlett-Packard. *Wokingham, Berks.* **277**

Portescap has published a comprehensive 24 page technical brochure on its families of **micro motors**. *Portescap, Reading, Berks.* **278**

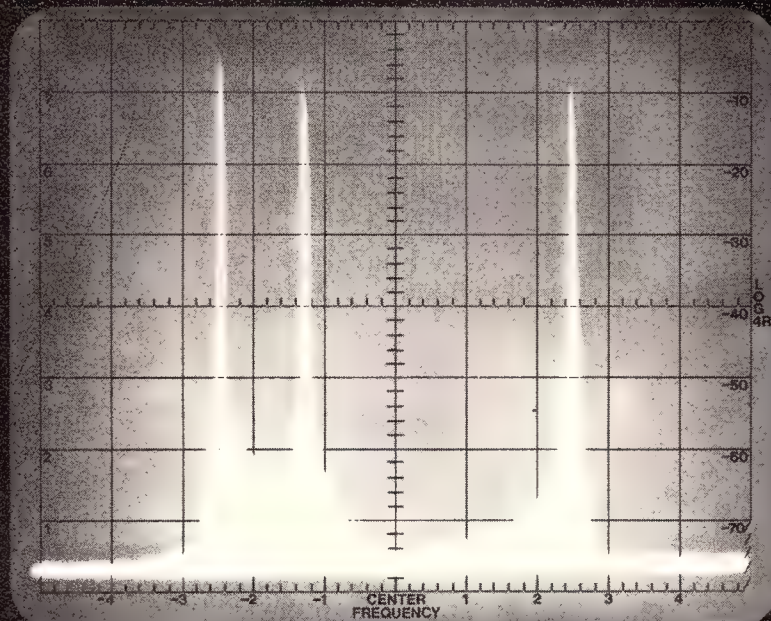
Intel has information on a **software system** for the 8080A microcomputer that allows programmes written in PL/M to be compiled on the 8080A itself. *Intel, Cowley, Oxford.* **279**

An update on a products and services booklet has been undertaken by BXL to give a comprehensive listing of the current range of **plastics** materials, semi-finished and finished products. *BXL, London.* **280**

An introduction to microcomputers, £4.50, gives the basics of **microcomputers** and an evaluation of the best known micros. *Pelco, Hove, Sussex.* **281**

Technical information is available on a non-capacitive solid state switch which

Impossible? Easy!



Obtainable by three controlled frequency changes within a single magnetron pulse.

NEW DATA

has been developed by **LDF Semiconductors, California, U.S.A.** 282

A brochure is available from Euro Instruments on the services and instruments the company is able to provide. **Euro, Co Meath, Eire.** 283

Technical information which describes the **DSG1 synthesized generator** can be obtained from **Farnell, Wetherby, West Yorkshire.** 284

A booklet from Lambda covers its 103 range of **voltage regulators** for dc power circuits from 150 mA to 30 A. **Lambda, High Wycombe, Bucks.** 285

A four page illustrated brochure from Licon gives information on the company's large range of **switches** from microswitches sealed switches through to illuminated push buttons. **Licon, Portsmouth, Hants.** 286

A four page leaflet entitled '**Micromesh and sieves**' is available from EMI which describes the division's standard range of precision micromesh. **EMI Electron Tube Division, Hayes, Middx.** 287

Information is available on the activities of Trio Labs and the range of **power supplies** the company manufactures. **Trio Laboratories, Hindhead, Surrey.** 288

A line of modular single phase **rectifier** assemblies, rated from 2 to 25 A is described in a technical data sheet available from **Westinghouse, Windsor, Berks.** 289

A leaflet is available detailing the range of **temperature sensors** produced by **Bush Beach Engineering, Cheadle Hulme, Cheshire.** 290

The 1976/77 catalogue from Hollingsworth features a range of **terminals**, splices and connectors as well as crimping tools. **Hollingsworth, Cheshington, Surrey.** 291

A 288 engineering product handbook from Datel contains information on **converters**, sample and hold circuits, op amps, power supplies etc. It can be obtained free from **Datel, Basingstoke, Hants.** 292

A data sheet from Solid State Controls describes the company's pc mini range of **temperature controllers.** **Solid State Controls, London.** 293

A leaflet from Clarke Olsen provides full technical specification and indicates more than 600 different ratios which are available using the company's **gears** and pinions. **Clarke Olsen, Birmingham.** 294

Memory Devices has announced the availability of an eight page leaflet for the advanced bipolar 57110/67110 **microprogram** control unit. **Memory Devices, East Molesey, Surrey.** 295

Another leaflet from Bush Beach deals with sampling **nozzles** and probes for sampling steam from high pressure boilers. **Bush Beach Engineering, Cheadle Hulme, Cheshire.** 296

The ERA hybrid microelectronics survey provides a concise description of **thick film** hybrid technology indicating its advantages and disadvantages compared with other forms of construction. **ERA, Leatherhead, Surrey.** 297

The magnavox MX 1102 satellite **navigator** is described in brochure available from **S G Brown, Watford, Herts.** 298

A four page product leaflet is available from LC Automation giving details of the company's range of **projectors** and receivers, photo-electric controls, timers and electronic counters. **LC Automation, Preston, Lancs.** 299

A 76 page brochure has been produced by UK Solenoid describing the range of **contactors**, relays, direct on line starters rotary switches and general purpose switches the company makes. **UK Solenoid, Newbury, Berks.** 300

A shortform catalogue has been published by Rosemount which gives information on its equipment for **aero-space** applications. **Rosemount, Bognor Regis, Sussex.** 301

A booklet entitled '**The protection of invention—a policy on patents**', £2.80 explains patent practice and can be obtained from **Patinel, Newcastle-on-Tyne.** 302

The electronic components division of Ferranti now has available its brochure on **vacuum** thick ceramic to metal seals. **Ferranti, Oldham, Lancs.** 303

A 12 page brochure on the smaller size **channel transistion** equipment offered by STC can be obtained from **STC, Newport, Gwent.** 304

Computer Automation has issued a free **minicomputer** wall chart that it claims to be the most up to date independent guide to US mini manufacturers. **Computer Automation, Rickmansworth, Herts.** 305

A booklet is available from Wallac Controls giving details of the **nuclear safety** instrumentation manufactured

and marketed by the company. **Wallac Controls, Newbury, Berks.** 306

A brochure has been prepared by Penny and Giles describing its range of **linear transducers** covering stroke lengths of from 0.05 in to 100 ins. **Penny and Giles, Christchurch, Dorset.** 307

The seventh edition of the U.K. **guide** to the electronic components business has been published by Eurolec. The 508 page book provides information on nearly 100 companies. **Eurolec, Chelmsford.** 308

A monthly list of **semiconductors** held in stock is now being produced by Distronic which includes diode, rectifiers, triacs and transistors. **Distronic, Harlow, Essex.** 309

The 38th diode data book has been expanded for the Autumn edition and contains information on over 3000 **devices**. £45.15 annual subscription. **London Information, Ascot, Berks.** 310

A ten page catalogue covering the BS 88 range of Brush industrial type **fuselinks** is now available from the **Compton Parkinson, Northampton.** 311

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This is how

With EEV's new MTM—the world's first electronically tuned magnetron.

EEV is proud to announce the Multipactor Tuned Magnetron.

For the first time, an effective method of electronic tuning for magnetrons is available.

EEV engineers have turned the multipactor phenomenon—until now a parasitic problem—to the advantage of magnetron users.

EEV's new patented MTM is basically an auxiliary resonant cavity which is coupled to the main magnetron anode. Several of these auxiliary cavities can be fitted to the same anode to increase the total frequency shift or to give a selection of frequencies.

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The MTM therefore solves the problems which are intrinsic in existing mechanical tuning systems. It offers frequency agility—a wide tuning range, and a tuning rate so fast that the frequency can be changed many times within a single pulse. Because it has no mechanism to wear out, it is dependable, durable and rugged in any environment. It is simple, and considerably less expensive than other tuning techniques.

Multipactor tuning can be applied to most magnetrons in the EEV range, offering random pulse to pulse frequency agility, pulse shaping, clutter decorrelation... the possibilities are enormous.

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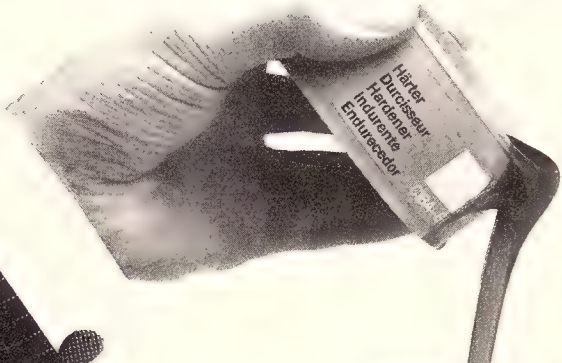
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Electronic Engineering November 1976

S&C 

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NEW DATA

A technical booklet is available from Merlin Gerlin on the company's range of programmable controllers. *Merlin Gerlin, Telford, Salop.* 312

Reliability has a catalogue available on its criteria chamber systems for electronic test systems. *Reliability, Ireland.* 313

A four page illustrated leaflet is now available from *Platt Power Transmission of Oldham, Lancs.* 314

Available from Technical Indexes is the new edition of Electronic Engineering Index—the information system covering electronics industry suppliers. *Technical Indexes, Bracknell, Berks.* 315

Technical information has been produced by Fluke on the 8500A digital voltmeter which has an accuracy of 0.001 per cent. *Fluke, Watford, Herts.* 316

The book, *Computer aided design of surface acoustic waves*, \$42.50 gives mathematical representation of surface acoustic waves. *Elsevier Scientific Publishing company, The Netherlands.* 317

Endress and Hauser has issued an explanatory brochure in level measurement using the non contact gamma technique. *Endress and Hauser, Manchester.* 318

The book *Noise in measurements*, £10.50 brings together a vast amount of information concerning the effects of noise on the accuracy of measurements, the publishers claim. *John Wiley and Sons, Chichester, Sussex.* 319

A 52 page booklet "Design engineer's guide to dc stepping and ac synchronous motors" is available from *Distronic, Harlow, Essex.* 320

Geometrical theory of diffraction for electromagnetic waves by Graeme L. James £13.50 gives an exposition of the formulation for vector fields. *Peter Peregrinus, Stevenage, Herts.* 321

Time Electronics has made additions and specification improvements to their range of dc voltage and current standards. Data sheets are available from *Time Electronics, Tonbridge, Kent.* 322

Sound Recording by J Eargle, £12.50 is broadly divided into two sections covering the fundamentals of sound recording and the devices and techniques used. *Van Nostrand Reinhold, Co, New York, U.S.A.* 323

Simple circuit building and Project planning and building are two more titles in the constructors guides from *Newnes Butterworth, Sevenoaks, Kent.* 324

Optical fibre technology, £13.50, considers the prospects of optical fibres in the communications field. *John Wiley and Sons, Chichester, Sussex.* 325

Details of the current specifications for thermal shock testing and equipment to meet these standards is described in an eight page brochure from *Euro Instruments, London.* 326

The IBA technical reviews eight and nine concern digital video processing dice and digital television developments copies can be obtained from *Engineering Information Service, IBA, Winchester, Hants.* 327

Another London Information book called the semiconductor application notes data book is separated into analogue circuits, digital circuits, general discrete device notes, general ic and microprocessor notes. £25.95 for a year's subscription. *London Information, Ascot, Berks.* 328

Number 20 of the technical scientific journal *Disa* information contains a number of papers on flow measuring problems. *Disa Elektronik A/S, Copenhagen, Denmark.* 329

Details of the range of engineering plastics available from Ciba Geigy is described in a brochure available from the company, *Ciba Geigy, Cambridge.* 330

Some of the many applications possible with Marconi Instruments TF2008 am/fm signal generator are described in a booklet produced by *Marconi Instruments, Chelmsford, Essex.* 331

An application note is available on the use of Measurement Technology's safety barrier for use in hazardous areas. *Measurement Technology, Luton, Beds.* 332

Another IBA review No 8 deals with service planning and propagation. *Engineering Information Service, IBA, Winchester, Hants.* 333

Reprints of an article "New digital techniques applied to rate measurement" describing recipromatic computation principle and basic operation of time interval conversion counters and their application are available from *Orbit Controls, Cheltenham, Glos.* 334

Frequency Synthesizers: theory and design is the title of a 523 page hardback by Vadim Manassevitch, engineering consultant, General Instrument Corp. According to the preface, the objective of this book is to provide training and reference material for engineers working in comms, radar and other areas where frequency synthesizers are used. £19.50; *John Wiley and Sons, Chichester, Sussex.* 335

Krohn-Hite filters, oscillators, phase-meters, power amplifiers, function generators and ancillary equipment is included in a shortform catalogue available from *Keithley Instruments, Reading, Berks.* 336

Magnetic tape recording equipment is described in a 24 page brochure available from *SE Labs (EMI) Ltd, Feltham, Middx.* 337

A 4 page guide explaining the Escap miniature permanent-magnet dc tachogenerators is available from *Portescap (UK), Reading.* 338

A leaflet on *DataLook* which monitors up to eight lines of logic information and stores the last 256 bytes clocked into the system is available from *Brensal Electronics, Bristol.* 339

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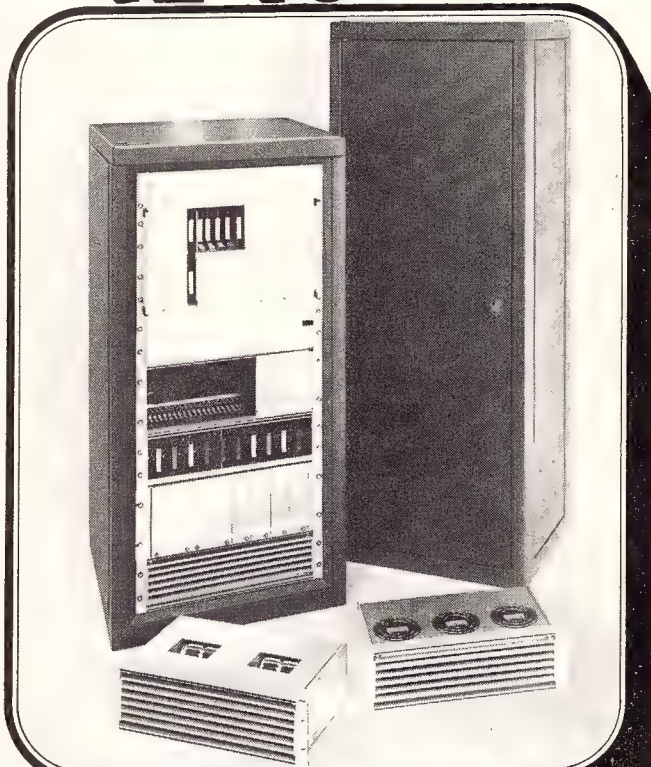
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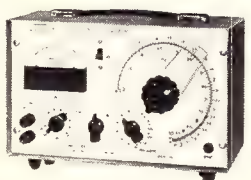
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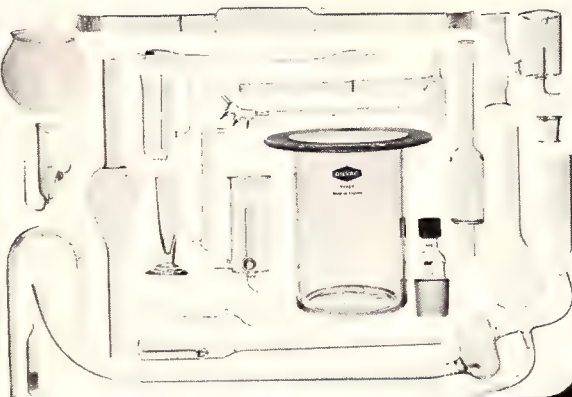
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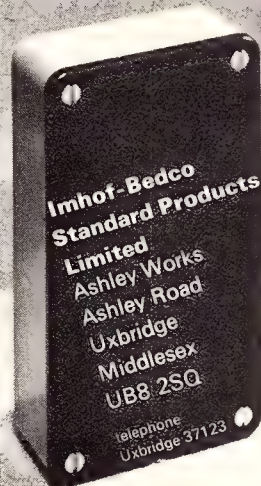
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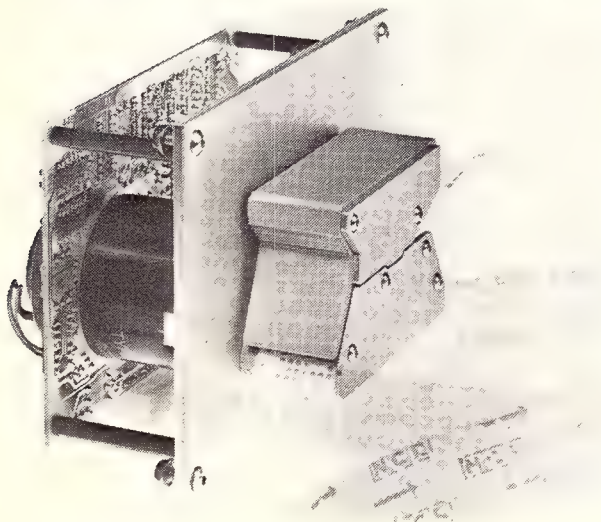
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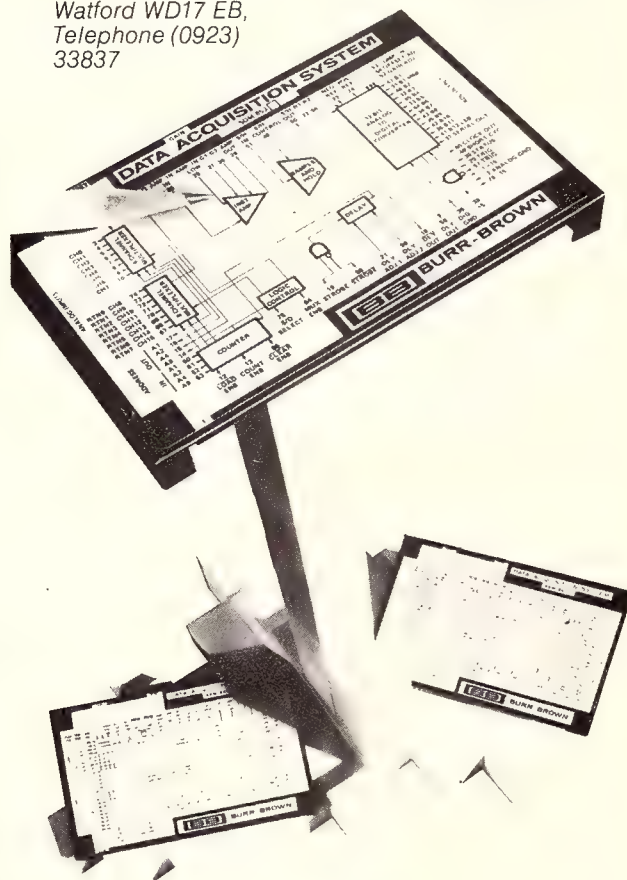
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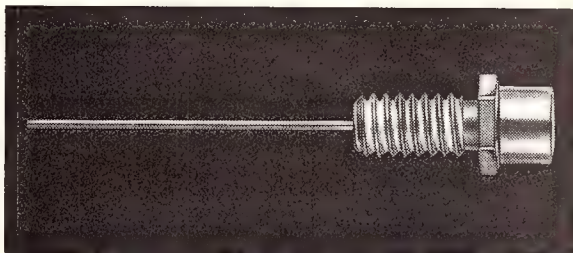


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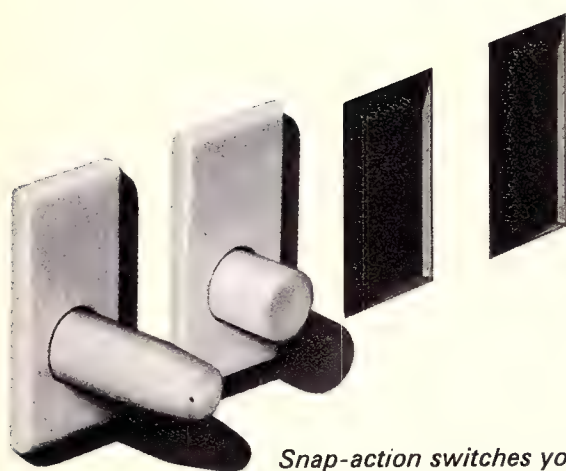
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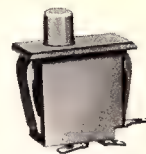
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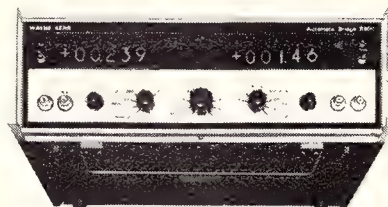


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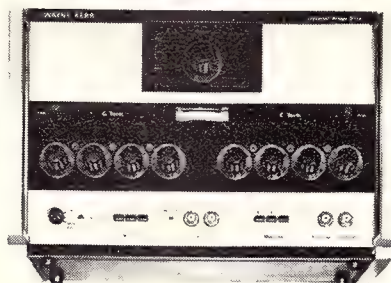
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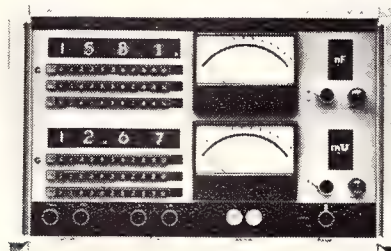
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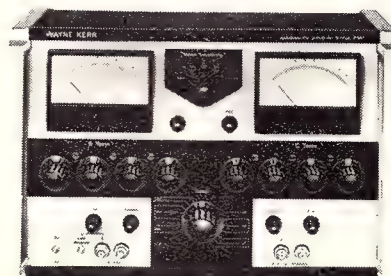
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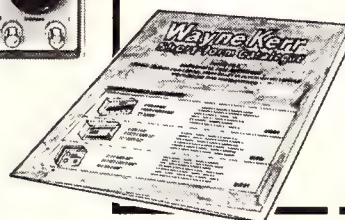
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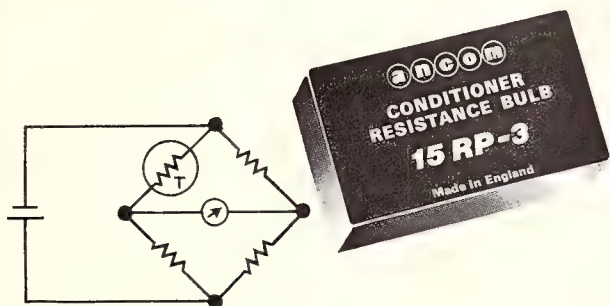
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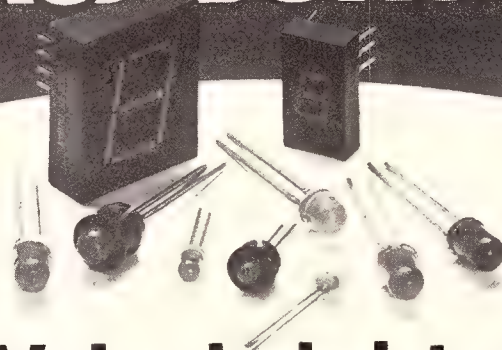
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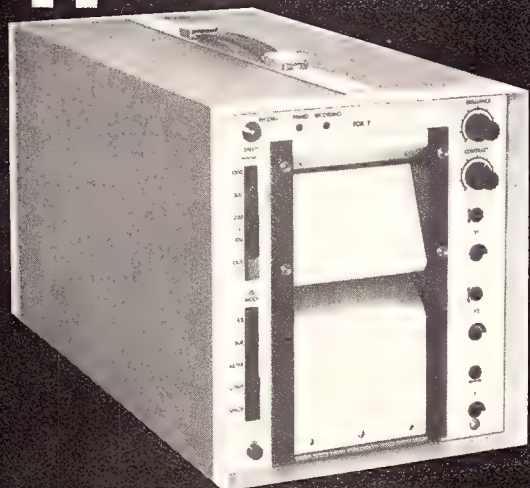
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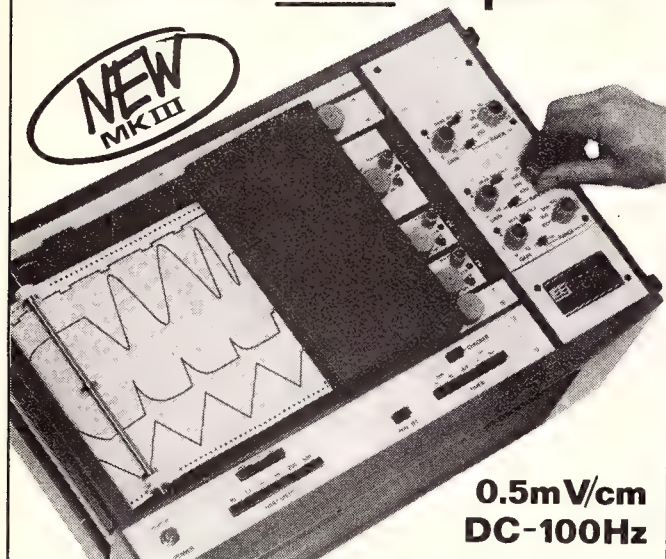
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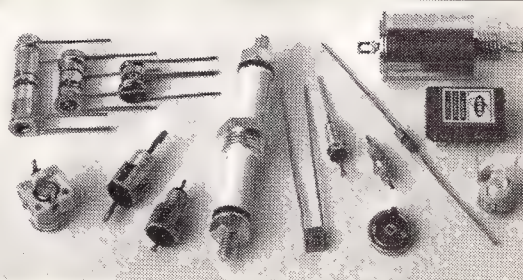
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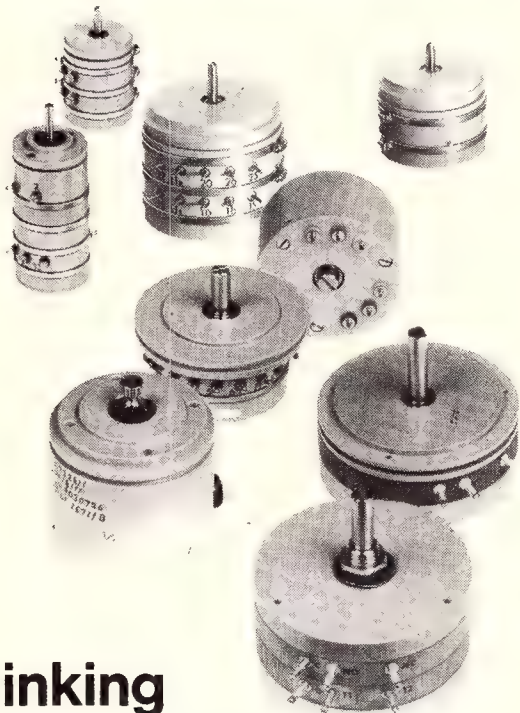
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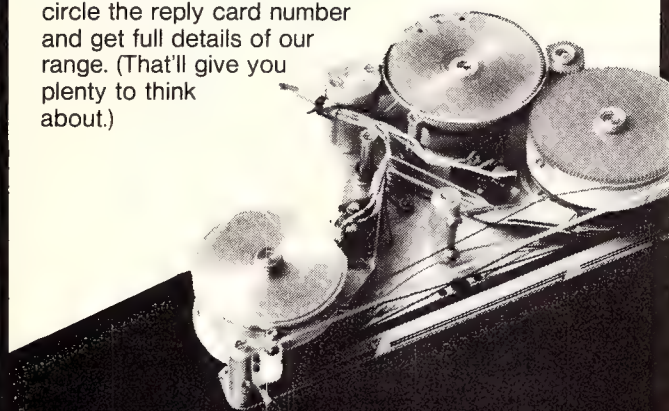
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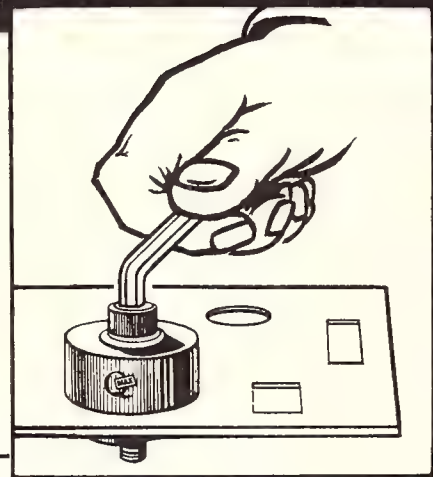
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AMP Ltd	33	Ferranti Ltd	82	Pye Unicam Ltd	26
Allen Bradley Electronics Ltd	2	GDS Ltd	24	Q-Max Electronics Ltd	112
Alma Components Ltd	6	GEC Semiconductors Ltd	42/43	RIFA	72
Amphenol-Tuchel GmbH	37	General Instruments Ltd	22	Racal Instruments Ltd	10/11
Analogue Ltd	75	Gould Advance Ltd	IBC, 63	Roxburgh Electronics Ltd	110
Ancom Ltd	110	Gresham Lion Ltd	59	SE Labs (EMI) Ltd	40, 105
Arrow-Hart (Europe) Ltd	8	Griffin Factors Ltd	62	SDS Components Ltd	113
Barr & Stroud Ltd	8	Harwin Engineering Ltd	67	Salford Electrical Instruments Ltd ..	87
Bourns Trimpot Ltd	35	Hellermann Electric Ltd	95	Shell Ltd	83
Brady, W H Ltd	94	Hengstler (GB) Ltd	12	Siliconix Ltd	78
Bulgin, A F & Co Ltd	104	Hunting Hivolt Ltd	87	Smiths Industries—Sintox	34
Burr Brown International Ltd	106	ITT Components Ltd	107	Sprague Electric (UK) Ltd	71
Cathodeon Crystals Ltd	116	ITT Instrument Services Ltd	18	TDK Electronics Co Ltd	36
Celdis Ltd	39	Imhof Bedco Ltd	104	Techmation Ltd	94
Cherry Electrical Ltd	108	Industrial Instruments Ltd	66	Technical Tapes Ltd	67
Ciba-Geigy (UK) Ltd	102	Intel Group Ltd	84/85	Technitron Ltd	72
Cliffpalm Ltd	116	International Rectifier Ltd	98	Teledyne Philbrick Ltd	38, 86
Combined Optical Ltd	12	Intersil Inc	14/15	Telford Development Corporation ..	92
Cosmocord Ltd	115	Levell Electronics Ltd	104	Teradyne Ltd	99
Coutant Electronics Ltd	30/31	Ling Dynamic Systems Ltd	86	Texas Instruments Ltd	80
Data General Ltd	76	Lyons Instruments Ltd	74	Thorn Radio Ltd	13
Data Precision Ltd	106	Magnetic Devices Ltd	57	Thorn Electrical Ltd	73
Day Impex Ltd	104	Malden Electronics Ltd	88/89	Varelco Ltd	41
Dexion Ltd	82	Marconi Instruments Ltd	111	Veeder Root Ltd	94
Diamond H Controls Ltd	38	Medelec Ltd	20, 32	Vero Electronics Ltd	74, 103
Dow Chemicals Ltd	68/69	Monsanto Ltd	Insert	Vision Engineering Ltd	57
ENI Power Systems Ltd	16	Mullard Ltd	OBC	Wallis Electronics Ltd	110
Electroplan Ltd	9	PSM Fasteners Ltd	112	Waycom Ltd	60, 64
English Electric Valve Co Ltd	100/101	Penny & Giles Ltd	70	Westinghouse Brake & Signal Ltd ..	52
Environmental Equipment Ltd	111	Pulse Engineering Ltd	90	Willmot Breedon Electronics Ltd ..	109
Erg Industrial Ltd	3	Pye Connectors Ltd			
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Erma Ltd	70				

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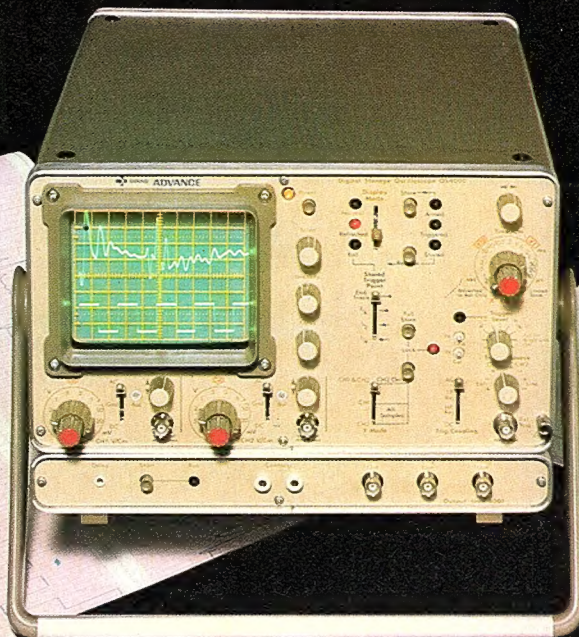
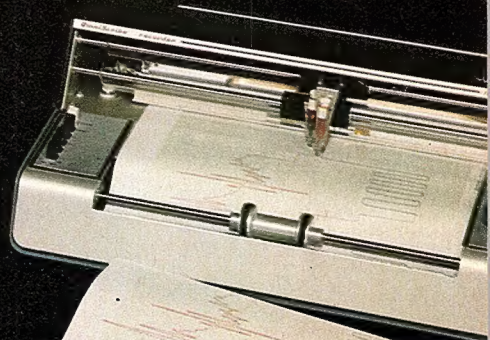
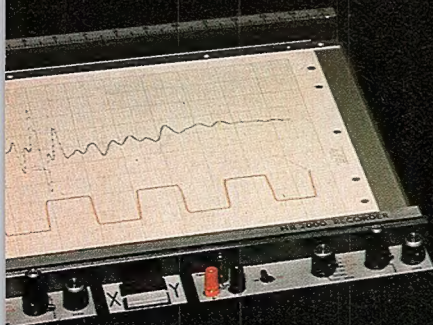
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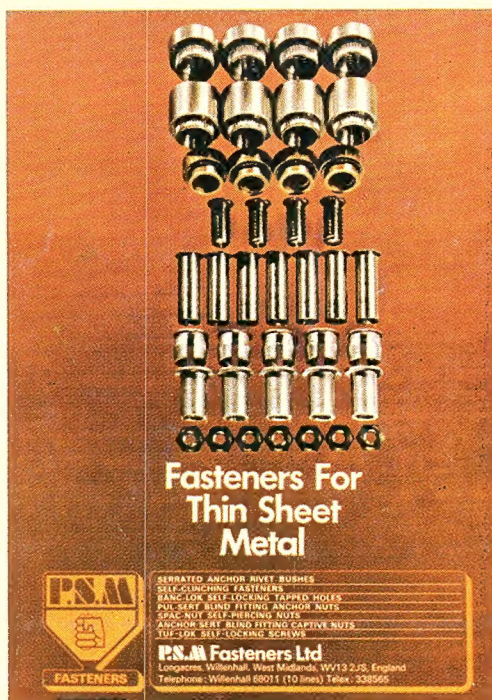
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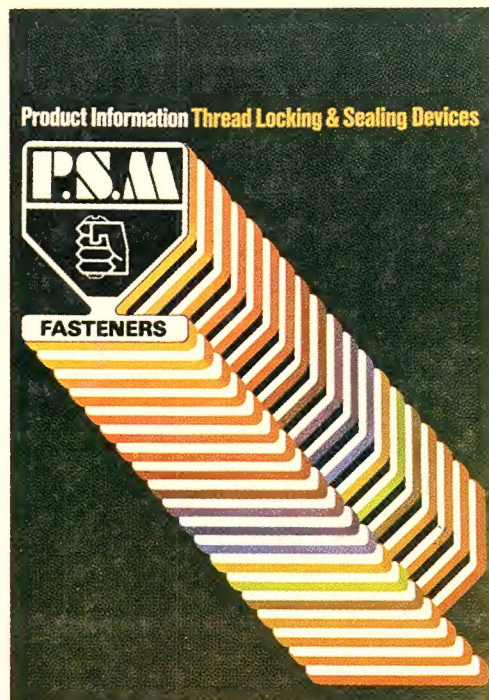
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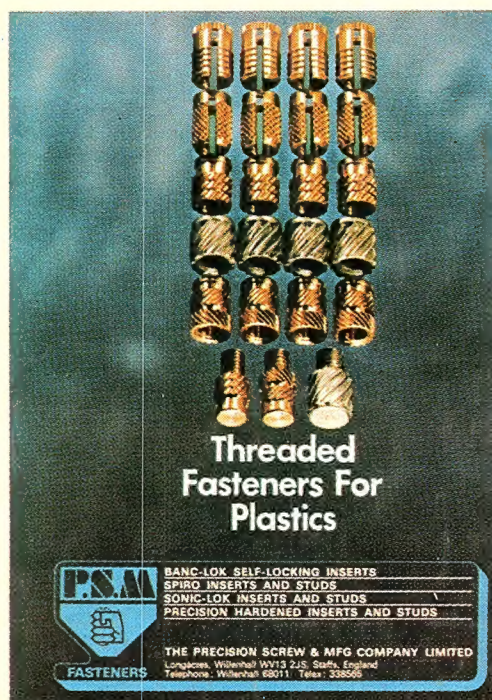
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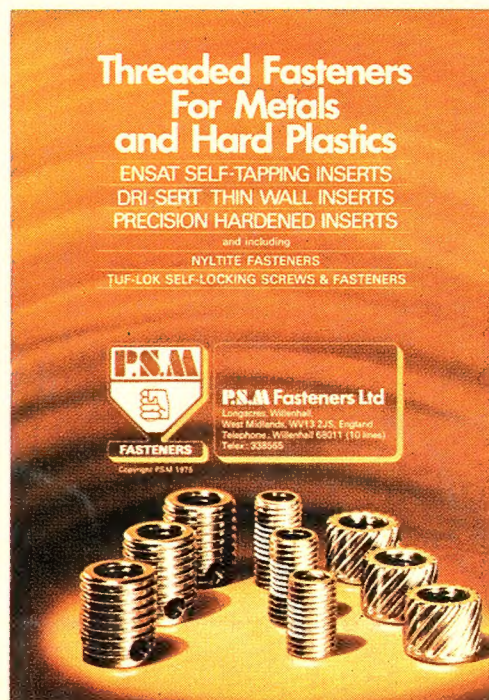
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